

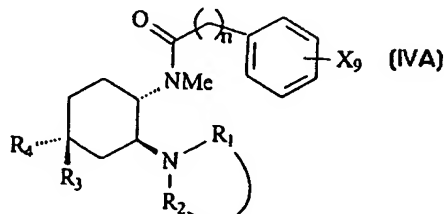
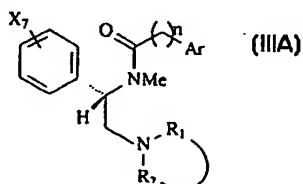
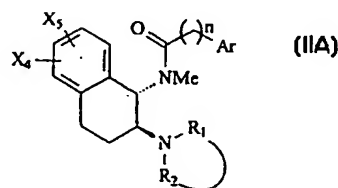
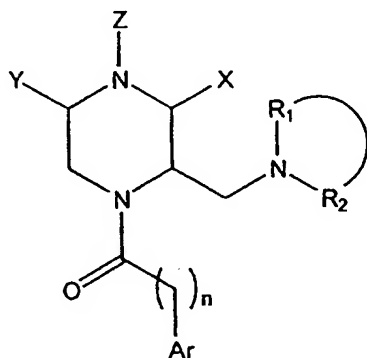
PCT

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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/US99/13680 (22) International Filing Date: 16 June 1999 (16.06.99) (30) Priority Data: 09/150,369 9 September 1998 (09.09.98) US (71) Applicant: ADOLOR CORPORATION [US/US]; 371 Phoenixville Pike, Malvern, PA 19355 (US). (72) Inventors: ZHANG, Wei, Yuan; 154 Hunsicker Drive, Collegeville, PA 19426 (US). MAYCOCK, Alan, L.; 1908 Standiford Drive, Malvern, PA 19355 (US). MARELLA, Michael, Anthony; 32 Carriage Lane, Exton, PA 19341 (US). KUMAR, Virendra; 14 Lynne Circle, Paoli, PA 19301 (US). GAUL, Forrest; 1781 Fairview Road, Glen Moore, PA 19343 (US). CHANG, An-Chih; Civic Square Apartments #225, Civic Center Drive, Rochester, MN 55096 (US). GUO, Deqi; 233 Lexington Drive, Phoenixville, PA 19460 (US). (74) Agent: BALOGH, Imre; 276 Smith School Road, Perkasic, PA 18944 (US).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CN, CU, CZ, EE, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: KAPPA AGONIST COMPOUNDS AND PHARMACEUTICAL FORMULATIONS THEREOF



## (57) Abstract

The invention relates to compounds of formulae (I), (IIA), (IIIA) and (IVA), processes of their preparation, pharmaceutical compositions and their use as kappa agonists.

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**KAPPA AGONIST COMPOUNDS AND PHARMACEUTICAL  
FORMULATIONS THEREOF**

5        This application is a continuation-in-part of Application Serial No. 09/034,661 filed  
on March 3, 1998, which in turn is a divisional of Application Serial No. 08/899,086 filed on  
July 23, 1997, now U.S. Patent No. 5,744,458, which in turn is a divisional of Application  
Serial No. 08/796,078, filed on February 5, 1997, now U.S. Patent No. 5,688,955, which in  
turn is a continuation of Application Serial No. 08/612,680, filed on March 8, 1996, now U.S.  
10   Patent No. 5,646,151.

**BACKGROUND OF THE INVENTION**

1. Field of the Invention

15        This invention relates to compounds, to processes of their preparation, to  
pharmaceutical compositions containing them and to their medical use as agonists at kappa  
opioid receptors.

2. Reported Developments

20        Opium and its derivatives are potent analgesics that also have other pharmacological  
effects, and exert their effects by interacting with high-affinity receptors.

It has been shown by investigators that there are at least three major opioid receptor  
types in the central nervous system (hereinafter CNS) and in the periphery. These receptors,  
known as mu ( $\mu$ ), delta ( $\delta$ ) and kappa ( $\kappa$ ), have distinct pharmacological profiles, anatomical  
25   distributions and functions. [See, for example: Wood, P.L., Neuropharmacology, 21, 487-  
497, 1982; Simon, E. J., Med. Res. Rev., 11, 357-374, 1991; Lutz et al, J. Recept. Res. 12,  
267-286; and Mansour et al, Opioid I, ed. Herz, A. (Springer, Berlin) pp. 79-106, 1993.] The  
 $\delta$  receptors are abundant in CNS and mediate analgesia, gastrointestinal motility and various  
hormonal functions. The  $\mu$  receptors bind morphine-like drugs and mediate the opiate  
30   phenomena associated with morphine, including analgesia, opiate dependence, cardiovascular  
and respiratory functions, and several neuroendocrine effects.

The  $\kappa$  receptors have a wide distribution in CNS and mediate a spectrum of functions  
including the modulation of drinking, water balance, food intake, gut motility, temperature  
control and various endocrine functions. They also produce analgesia. [See, for example:  
35   Leander et al, J. Pharmacol. Exp. Ther. 234, 463-469, 1985; Morley et al, Peptides 4, 797-  
800, 1983; Manzanares et al, Neuroendocrinology 52, 200-205, 1990; and Iyengar et al, J.  
Pharmacol. Exp. Ther, 238, 429-436, 1986.]

Most clinically used opioid analgesics such as morphine and codeine act as  $\mu$  receptor agonists. These opioids have well-known, undesirable and potentially dangerous dependence forming side effects. Compounds which are  $\kappa$ -receptor agonists act as analgesics through interaction with  $\kappa$  opioid receptors. The advantage of these agonists over the classical  $\mu$  receptor agonists, such as morphine, lies in their ability to cause analgesia while being devoid of morphine-like behavioral effects and addiction liability.

A large number of classes of compounds which act as agonists at  $\kappa$  opioid receptors have been described in the art including the following illustrative classes of compounds.

U.S. Patent No. 4,065,573 discloses 4-amino-4-phenylcyclohexane ketal compounds having analgesic activity.

U.S. Patent No. 4,212,878 discloses phenylacetamide derivatives having analgesic properties and reduced physical dependence liability properties, relative to morphine and methadone.

U.S. Patent No. 4,145,435 discloses N-(2-amino-cycloaliphatic)-phenylacetamide compounds having analgesic activity and narcotic antagonist activity.

U.S. Patent No. 4,098,904 discloses N-(2-amino-cycloaliphatic)-benzoamides and naphthamides useful for relieving pain.

U.S. Patent No. 4,359,476 discloses substituted cycloalkane-amides useful as analgesic and having low abuse liability.

U.S. Patent No. 4,438,130 discloses 1-oxa-, aza- and thia-spirocyclic compounds having analgesic activity, low physical dependence and abuse liability properties and little dysphoric inducing properties.

U.S. Patent No. 4,663,343 discloses substituted naphthalenyloxy-1,2-diaminocyclohexyl amides as analgesics.

U.S. Patent No. 4,906,655 discloses 1,2-cyclohexylaminoaryl amides having high kappa-opioid affinity, selectivity and potency and useful as analgesics, diuretics, anti-inflammatory and psychotherapeutic agents.

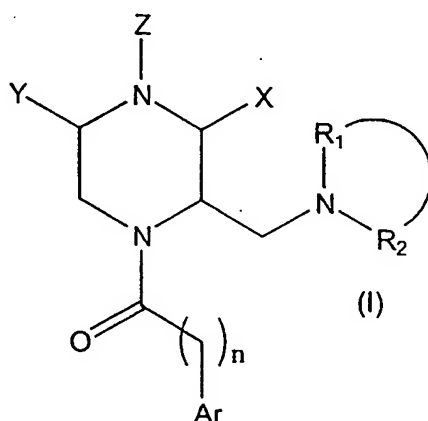


SUMMARY OF THE INVENTION

Compounds having kappa opioid agonist activity, compositions containing them and method of using them as analgesics are provided.

5 In its compound aspect, the present invention provides a compound of the formulae I, II, IIA, III, IIIA, IV and IVA, or a pharmaceutically acceptable salt thereof.

The compounds of formula (I) have the following structure:



10 wherein

$n=1-3$ , where  $n=1$  is preferred

$R_1$  and  $R_2$  are independently  $=CH_3$ ;  $-(CH_2)_m$ , where  $m=$

4-8,  $m=4$  is most preferred;  $-CH_2CH(OH)(CH_2)_2-$ ;

$CH_2CH(F)(CH_2)_2-$ ;  $-(CH_2)_2O(CH_2)_2-$ ; or

15  $-(CH_2)_2CH=CHCH_2-$ ;

Ar = unsubstituted or mono- or di-substituted phenyl

wherein said substituents are selected from the group

consisting of halogen,  $OCH_3$ ,  $SO_2CH_3$ ,  $CF_3$ , amino, alkyl,

and 3,4-dichloro; benzothiophenyl; benzofuranyl; naphthyl;

20 diphenyl methyl; or 9-fluorene;

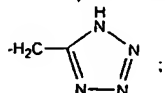
Z is

$-P(O)(OBn)_2$ ;  $-P(O)(OH)_2$ ;  $-(CH_2)_pC(O)NHOH$ ;  $-(CH_2)_pCO_2H$ ;  $-SO_2CH_3$ ;  $-SO_2NH_2$ ;

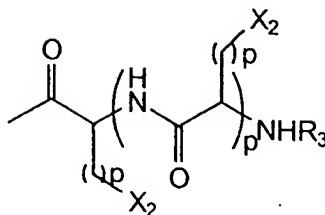
$-CO(CH_2)_pCH(NH_2)(CO_2H)$ ;  $-COCH(NH_2)(CH_2)_pCO_2H$ ;  $-CO_2CH_3$ ;  $-CONH_2$ ;

25  $-(CH_2)_pO(CH_2)_pCO_2H$ ;  $-(CH_2)_pO(CH_2)_pCONHOH$ ;  $-(CH_2)_pNHOSO_2CH_3$ ;

$-(CH_2)_pNHC(S)NHCH(CO_2H)(CH_2)_pCO_2H$ ;  $-(CH_2)_pSO_3H$ ; or



or Z is



wherein

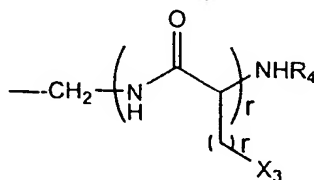
p = 0-20;

R<sub>3</sub> = -H or -Ac;

X<sub>2</sub> = -CO<sub>2</sub>H; -NHSO<sub>2</sub>CH<sub>3</sub>; NHP(O)(OBn)<sub>2</sub>; NHP(O)(OH)<sub>2</sub>;  
-OP(O)(OBn)<sub>2</sub>; or OP(O)(OH)<sub>2</sub>;

X and Y are independently

-CH<sub>2</sub>NHSO<sub>2</sub>CH<sub>3</sub>, -CH<sub>2</sub>NHP(O)(OBn)<sub>2</sub>, -CH<sub>2</sub>NHP(O)(OH)<sub>2</sub>, -CH<sub>2</sub>OP(O)(OBn)<sub>2</sub>,  
-CH<sub>2</sub>OP(O)(OH)<sub>2</sub>, -(CH<sub>2</sub>)<sub>q</sub>O(CH<sub>2</sub>)<sub>q</sub>CO<sub>2</sub>H, -(CH<sub>2</sub>)<sub>q</sub>O(CH<sub>2</sub>)<sub>q</sub>SO<sub>3</sub>H,  
-(CH<sub>2</sub>)<sub>q</sub>O(CH<sub>2</sub>)<sub>q</sub>CHNHOH,  
-CH<sub>2</sub>NHC(S)NHCH(CO<sub>2</sub>H)(CH<sub>2</sub>)<sub>q</sub>CO<sub>2</sub>H or



wherein

r = 1-20

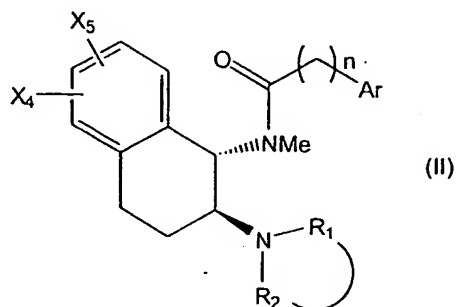
R<sub>4</sub> = -H or -Ac

X<sub>3</sub> = -CO<sub>2</sub>H; -NHSO<sub>2</sub>CH<sub>3</sub>; -NHP(O)(OBn)<sub>2</sub>;

-NHP(O)(OH)<sub>2</sub>; -OP(O)(OBn)<sub>2</sub>; or

-OP(O)(OH)<sub>2</sub>.

The compounds of formula II have the following structure:



wherein

n=1-3, where n=1 is preferred

$R_1$  and  $R_2$  are independently =  $\text{CH}_3$ ;  $-(\text{CH}_2)_m$ , where  $m=$

4-8,  $m=4$  is most preferred;  $-\text{CH}_2\text{CH}(\text{OH})(\text{CH}_2)_2$ ;

$\text{CH}_2\text{CH}(\text{F})(\text{CH}_2)_2$ ;  $-(\text{CH}_2)_2\text{O}(\text{CH}_2)_2$ ; or

$-(\text{CH}_2)_2\text{CH}=\text{CHCH}_2$ ;

Ar = unsubstituted or mono- or di-substituted phenyl

wherein said substituents are selected from the group

consisting of halogen,  $\text{OCH}_3$ ,  $\text{SO}_2\text{CH}_3$ ,  $\text{CF}_3$ , amino, alkyl,

and 3,4-dichloro; benzothiophenyl; benzofuranyl; naphthyl;

diphenyl methyl; or 9-fluorene;

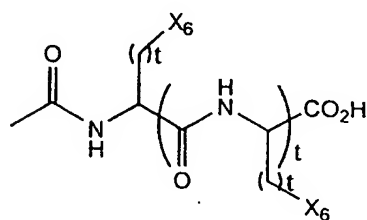
$X_4$  and  $X_5$  are independently

$-\text{OP}(\text{O})(\text{OBn})_2$ ;  $-\text{OP}(\text{O})(\text{OH})_2$ ;  $-\text{CO}_2\text{H}$ ;  $-\text{SO}_3\text{H}$ ;  $-\text{SO}_3\text{H}$ ;  $-\text{O}(\text{CH}_2)_n\text{CO}_2\text{H}$ ;

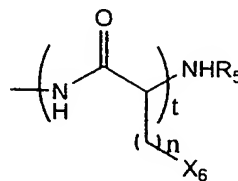
$-\text{NHSO}_2\text{CH}_3$ ;  $-\text{CONH}(\text{CH}_2)_s\text{CO}_2\text{H}$ ; or  $-\text{SO}_2\text{NH}(\text{CH}_2)_s\text{CO}_2\text{H}$ ; wherein

$s = 1-5$

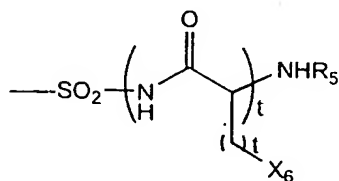
or  $X_4$  and  $X_5$  are independently



; or



; or



wherein

$t = 1-20$

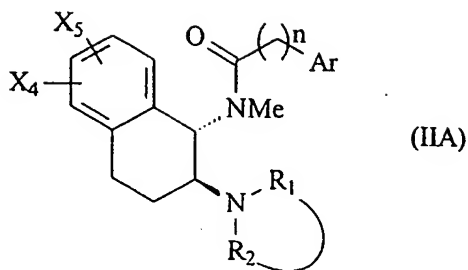
$R_5 = -\text{H}$  or  $-\text{Ac}$

$X_6 = -\text{CO}_2\text{H}$ ;  $-\text{NHSO}_2\text{CH}_3$ ;  $-\text{NHP}(\text{O})(\text{OBn})_2$ ;

$-\text{NHP}(\text{O})(\text{OH})_2$ ;  $-\text{OP}(\text{O})(\text{OBn})_2$ ; or

$-\text{OP}(\text{O})(\text{OH})_2$ .

The compounds of formula IIA have the following structure:



wherein

$n=1-3$ , where  $n=1$  is preferred

$R_1$  and  $R_2$  are independently  $=CH_3$ ;  $-(CH_2)_m$ , where  $m=$

4-8,  $m=4$  is most preferred;  $-CH_2CH(OR)(CH_2)_2-$  wherein  $R$  is H, alkyl, acyl or aroyl;  $CH_2CH(F)(CH_2)_2-$ ;  $-(CH_2)_2O(CH_2)_2-$ ; or  $-(CH_2)_2CH=CHCH_2-$ ;

$Ar$  = mono- or di-substituted phenyl; wherein said substituents are selected from the group consisting of halogen,  $OCH_3$ ,  $OH$ ,  $SO_2CH_3$ ,  $CF_3$ ,  $NH_2$ , alkyl, CN, unsubstituted and substituted sulfamoyl groups;

$Ar$  may also be substituted with

$-NH(CH_2)_uCO_2R'$ ;  $-NH(CH_2)_u(CH=CH)_u(CH_2)CO_2R'$ ;

$-NHCO(CH_2)_u(CH=CH)_u(CH_2)_uCO_2R'$ ;  $-NHP(O)(OBn)_2$ ;  $-NHP(O)(OR')_2$ ;

$-(CH_2)_uNHSO_2CH_3$ ;  $-(CH_2)_uNHC(S)NHCH(CO_2R')(CH_2)_uCO_2R'$ ;

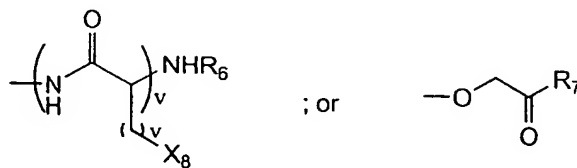
$-CONHOH$ ; or  $-(CH_2)_uCONHOH$ ;

wherein

$u = 0-5$ ;

$R' = H$  or lower alkyl;

or  $Ar$  is



$R_6 = -H$  or  $-Ac$

$X_8 = -CO_2H$ ;  $-NHSO_2CH_3$ ;  $-NHP(O)(OBn)_2$ ;  
 $-NHP(O)(OH)_2$ ;  $-OP(O)(OBn)_2$ ; or  
 $-OP(O)(OH)_2$ ;

$R_7 = -NH(CH_2)_vCO_2H$ ;  $-NH(CH_2)_vCH(NH_2)(CO_2H)$ ;  
 $-NHCH(CO_2H)(CH_2)_vNH_2$ ;  $-NH(CH_2)_vSO_3H$ ;  
 $-NH(CH_2)_vPO_3H_2$ ;  $-NH(CH_2)_vNHC(NH)NH_2$ ; or  
 $-NHCH(CO_2H)(CH_2)_vCO_2H$ ; and

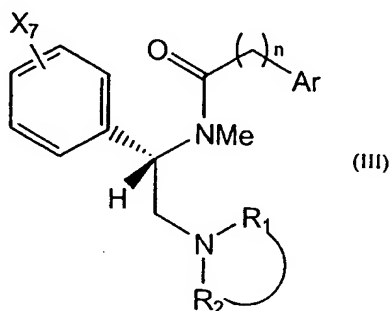
$v = 1-20$ .

$X_4$  and  $X_5$  are independently H; halogen; OH;  $OCH_3$ ;  $CF_3$ ;  $NO_2$ ;  $NH_2$ ; amino substituted with acyl, carbamate, alkyl or aryl sulfonates;  $COR'$  where  $R'$  is OH, amide, alkoxy, aryloxy or heteroaryloxy.

Compounds of formula (IIA) have at least one chiral center and may exist in more than one diastereoisomeric form. The invention includes within its scope all enantiomers, and diastereoisomers and the mixtures thereof.

5

The compounds of formula III have the following structure:



wherein

10

$n=1-3$ , where  $n=1$  is preferred

$R_1$  and  $R_2$  are independently  $=CH_3$ ;  $-(CH_2)_m$ , where  $m=$   
4-8,  $m=4$  is most preferred;  $-CH_2CH(OH)(CH_2)_2-$ ;

$CH_2CH(F)(CH_2)_2-$ ;  $-(CH_2)_2O(CH_2)_2-$ ; or  
 $-(CH_2)_2CH=CHCH_2-$ ;

15

$Ar$  = unsubstituted or mono- or di-substituted phenyl  
wherein said substituents are selected from the group  
consisting of halogen,  $OCH_3$ ,  $SO_2CH_3$ ,  $CF_3$ , amino, alkyl,  
and 3,4-dichloro; benzothiophenyl; benzofuranyl; naphthyl;  
diphenyl methyl; or 9-fluorene;

$X_7$  is

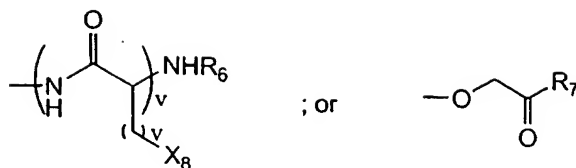
$-NHSO_2CH_3$ ;  $-NHP(O)(OBn)_2$ ;  $-NHP(O)(OH)_2$ ;  $-(CH_2)_uNHSO_2CH_3$ ;

$-(CH_2)_uNHC(S)NHCH(CO_2H)(CH_2)_uCO_2H$ ;  $-CONHOH$ ; or  $-(CH_2)_uCONHOH$ ;

wherein

$u = 1-5$

20 or  $X_7$  is



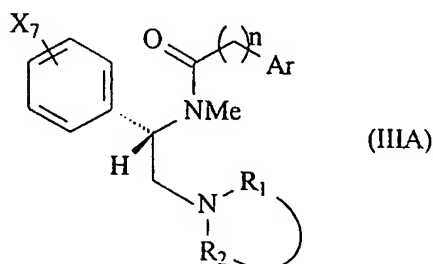
$R_6 = -H$  or  $-Ac$

$X_8 = -CO_2H$ ;  $-NHSO_2CH_3$ ;  $-NHP(O)(OBn)_2$ ;  
 $-NHP(O)(OH)_2$ ;  $-OP(O)(OBn)_2$ ; or  
 $-OP(O)(OH)_2$ ;

$R_7 = -NH(CH_2)_vCO_2H$ ;  $-NH(CH_2)_vCH(NH_2)(CO_2H)$ ;  
 $-NHCH(CO_2H)(CH_2)_vNH_2$ ;  $-NH(CH_2)_vSO_3H$ ;  
 $-NH(CH_2)_vPO_3H_2$ ;  $-NH(CH_2)_vNHC(NH)NH_2$ ; or  
 $-NHCH(CO_2H)(CH_2)_vCO_2H$ ; and  
 $v = 1-20$ .

5

The compounds of formula IIIA have the following structure:



10 wherein

$n=1-3$ , where  $n=1$  is preferred;

$R_1$  and  $R_2$  are independently  $=CH_3$ ;  $-(CH_2)_m$ , where  $m=$

$4-8$ ,  $m=4$  is most preferred;  $-CH_2CH(OR)(CH_2)_2-$ , wherein  $R=H$ , alkyl, acyl or aroyl;  
 $CH_2CH(F)(CH_2)_2-$ ;  $-(CH_2)_2O(CH_2)_2-$ ; or  $-(CH_2)_2CH=CHCH_2-$ ;

15

$Ar$  = mono- or di-substituted phenyl; wherein said substituents are selected from the group consisting of halogen,  $OCH_3$ ,  $OH$ ,  $SO_2CH_3$ ,  $CF_3$ ,  $NH_2$ , alkyl, CN, unsubstituted and substituted sulfamoyl groups;

$Ar$  may also be substituted with

20

$-NH(CH_2)_uCO_2R'$ ;  $-NH(CH_2)_u(CH=CH)_u(CH_2)_uCO_2R'$ ;  
 $-NHCO(CH_2)_u(CH=CH)_u(CH_2)_uCO_2R'$ ;  $-NHP(O)(OBn)_2$ ;  $-NHP(O)(OR')_2$ ;  
 $-(CH_2)_uNHCO_2CH_3$ ;  $-(CH_2)_uNHC(S)NHCH(CO_2R')(CH_2)_uCO_2R'$ ;  
 $-CONHOH$ ; or  $-(CH_2)_uCONHOH$ ;

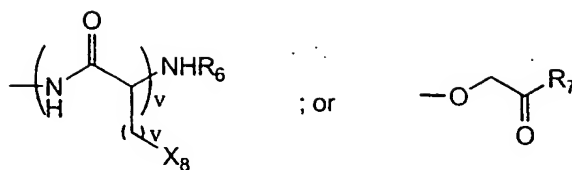
wherein

$u = 0-5$ ;

25

$R' = H$  or lower alkyl;

or  $Ar$  is



$R_6 = -H$  or  $-Ac$

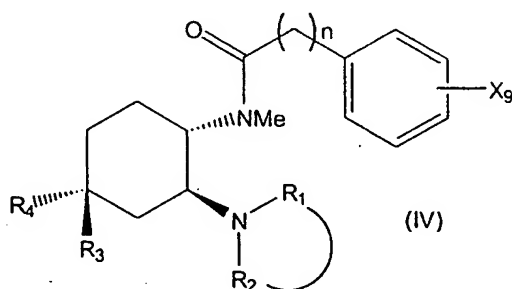
$X_8 = -CO_2H$ ;  $-NHSO_2CH_3$ ;  $-NHP(O)(OBn)_2$ ;  
 $-NHP(O)(OH)_2$ ;  $-OP(O)(OBn)_2$ ; or  
 $-OP(O)(OH)_2$ ;

$R_7 = -NH(CH_2)_vCO_2H$ ;  $-NH(CH_2)_vCH(NH_2)(CO_2H)$ ;  
 $-NHCH(CO_2H)(CH_2)_vNH_2$ ;  $-NH(CH_2)_vSO_3H$ ;  
 $-NH(CH_2)_vPO_3H_2$ ;  $-NH(CH_2)_vNHC(NH)NH_2$ ; or  
 $-NHCH(CO_2H)(CH_2)_vCO_2H$ ; and  
 $v = 1-20$ .

$X_7$  is H; halogen; OH;  $OCH_3$ ;  $CF_3$ ;  $NO_2$ ;  $NH_2$ ; amino substituted with acyl, carbamate, alkyl  
 5 or aryl sulfonates;  $COR'$  where  $R'$  is OH, amide, alkoxy, aryloxy or heteroaryloxy.

Compounds of formula (IIIA) have at least one chiral center and may exist in more than one  
 diastereoisomeric form. The invention includes within its scope all enantiomers, and  
 10 diastereoisomers and the mixtures thereof.

The compounds of formula IV have the following structure:



15

wherein

$n=1-3$ , where  $n=1$  is preferred

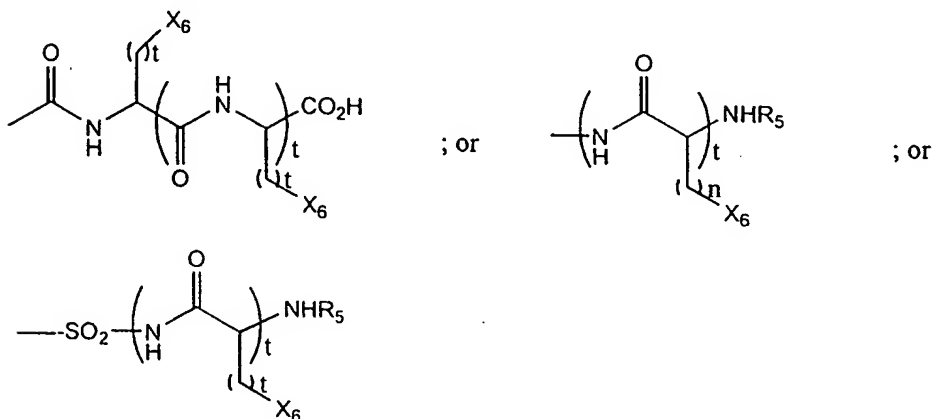
$R_1$  and  $R_2$  are independently  $=CH_3$ ;  $-(CH_2)_m$ , where  $m=4-8$ ,  
 $m=4$  is most preferred;  $-CH_2CH(OH)(CH_2)_2-$ ;  $CH_2CH(F)(CH_2)_2-$ ;  
 20  $-(CH_2)_2O(CH_2)_2-$ ; or  $-(CH_2)_2CH=CHCH_2-$ ;

$R_3$  and  $R_4$  are independently H;  $OCH_3$ ; alkyl; or  $C-O(CH_2)_2$ ;

$X_9 = 1-4$  substituents selected from the groups consisting of

-halogen;  $-\text{CF}_3$ ;  $-\text{OCH}_3$ ;  $-\text{SO}_2\text{NH}(\text{CH}_2)_q\text{CO}_2\text{H}$ ;  $-\text{CONH}(\text{CH}_2)_q\text{CO}_2\text{H}$ ;  
 $-\text{NH}_2$ ;  $-\text{NHSO}_2\text{CH}_3$ ;  $-\text{NHP}(\text{O})(\text{OBn})_2$ ;  $-\text{NHP}(\text{O})(\text{OH})_2$ ;  $-\text{SO}_2\text{CH}_3$ ;  
 $-\text{OP}(\text{O})(\text{OBn})_2$ ;  $-\text{OP}(\text{O})(\text{OH})_2$ ;  $-\text{CO}_2\text{H}$ ;  $-\text{O}(\text{CH}_2)_q\text{CO}_2\text{H}$ ;  $-\text{O}(\text{CH}_2)_q\text{SO}_3\text{H}$ ;  
 $-\text{O}(\text{CH}_2)_q\text{OPO}_3\text{H}_2$ ; wherein  
 $q = 1-20$ .

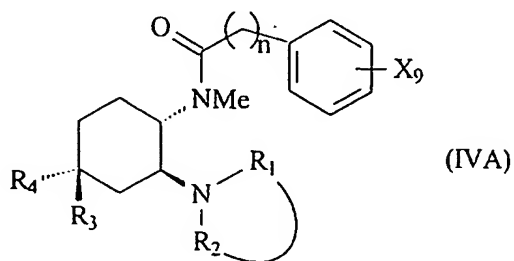
or  $X_6$  is



- 5 wherein  
 $t = 1-20$   
 $R_5 = -\text{H}$  or  $-\text{Ac}$   
 $X_6 = -\text{CO}_2\text{H}$ ;  $-\text{NHSO}_2\text{CH}_3$ ;  $-\text{NHP}(\text{O})(\text{OBn})_2$ ;  
 $-\text{NHP}(\text{O})(\text{OH})_2$ ;  $-\text{OP}(\text{O})(\text{OBn})_2$ ; or  
 $-\text{OP}(\text{O})(\text{OH})_2$ .

The compounds of formula IVA have the following structure:

10



wherein

- $n=1-3$ , where  $n=1$  is preferred  
 $R_1$  and  $R_2$  are independently  $=\text{CH}_3$ ;  $-(\text{CH}_2)_m$ , where  $m=4-8$ .

15



$m=4$  is most preferred;  $-\text{CH}_2\text{CH}(\text{OR})(\text{CH}_2)_2-$ ; wherein  $\text{R} = \text{H}$ , alkyl, acyl, or aroyl;  
 $\text{CH}_2\text{CH}(\text{F})(\text{CH}_2)_2-$ ;  $-(\text{CH}_2)_2\text{O}(\text{CH}_2)_2-$ ; or  $-(\text{CH}_2)_2\text{CH}=\text{CHCH}_2-$ ;

$\text{R}_3$  and  $\text{R}_4$  are independently  $\text{H}$ ;  $\text{OCH}_3$ ; alkyl; or  $-\text{O}(\text{CH}_2)_2$ ;

$\text{X}_9 = 1-4$  substituents selected from the groups consisting of

-halogen;  $-\text{CF}_3$ ;  $\text{OH}$ ,  $-\text{OCH}_3$ ;  $-\text{SO}_2\text{NH}(\text{CH}_2)_q\text{CH}_3$ ;  $-\text{NH}(\text{CH}_2)_q\text{COR}'$ ;

$-\text{NH}(\text{CH}_2)_q(\text{CH}=\text{CH})_q(\text{CH}_2)_q\text{CO}_2\text{R}'$ ;  $-\text{NH}(\text{CH})_q(\text{CH}=\text{CH})_q(\text{CH})_q\text{CO}_2\text{R}$ ;

$-\text{NHCO}(\text{CH}_2)_q(\text{CH}=\text{CH})_q(\text{CH}_2)_q\text{CO}_2\text{R}$ ; and  $-\text{NHCO}(\text{CH})_q(\text{CH}=\text{CH})_q(\text{CH})_q\text{CO}_2\text{R}'$

wherein

$q = 0-20$

$\text{R}' = \text{OH}$ , lower alkyl, aryl ester or aryl amide.

Compounds of formula (IVA) have at least one chiral center and may exist in more than one  
 diastereoisomeric form. The invention includes within its scope all enantiomers, and  
 diastereoisomers and the mixtures thereof.

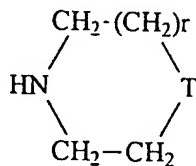
The meaning of the terms used in the specification and the claims, unless otherwise  
 denoted, are as follows.

The term "alkyl" as used herein alone or as part of another group, denotes optionally  
 substituted, straight and branched chain saturated hydrocarbon groups, preferably having 1 to  
 12 carbons in the normal chain, most preferably lower alkyl groups. Exemplary unsubstituted  
 groups include methyl, ethyl, propyl, isopropyl, n-butyl, t-butyl, isobutyl, pentyl, hexyl,  
 isohexyl, 4,4-dimethylpentyl, octyl, 2,2,4-trimethylpentyl, nonyl, decyl, undecyl, dodecyl and  
 the like. Exemplary substituents include one or more of the following groups: halo, alkoxy,  
 arylalkyloxy (e.g., benzyloxy), alkylthio, alkenyl, alkynyl, aryl, cycloalkyl, cycloalkenyl,  
 hydroxy, carboxyl ( $-\text{COOH}$ ), amino, alkylamino, dialkylamino, formyl, alkylcarbonyloxy,  
 alkylcarbonyl, heterocyclo, aryloxy or thiol ( $-\text{SH}$ ). Preferred alkyl groups are unsubstituted  
 alkyl, haloalkyl, arylalkyl, aminoalkyl, alkylaminoalkyl, dialkylaminoalkyl, alkoxyalkyl,  
 aryloxyalkyl, hydroxyalkyl and alkoxyalkyl groups.

The term "lower alkyl" as used herein denotes such optionally substituted groups as  
 described above for alkyl having 1 to 4 carbon atoms in the normal chain.

The terms "ar" or "aryl" as used herein or as part of another group, denote optionally substituted, homocyclic aromatic groups, preferably containing 1 or 2 rings and 6 to 12 ring carbons. Exemplary unsubstituted groups include phenyl, biphenyl and naphthyl. Exemplary substituents include one or more, preferably three or fewer, nitro groups, alkyl groups as described above, and/or one or more groups described above as alkyl substituents. Preferred aryl groups are unsubstituted aryl and hydroxyaryl.

The terms "heterocyclo" or "heterocyclic" as used herein alone or as part of another group, denote optionally substituted fully saturated or unsaturated, aromatic or non-aromatic cyclic groups having at least one heteroatom in at least one ring, preferably monocyclic or bicyclic groups having 5 or 6 atoms in each ring. The heterocyclo group may, for example, have 1 or 2 oxygen atoms, 1 or 2 sulfur atoms, and/or 1 to 4 nitrogen atoms in the ring. Each heterocyclo group may be bonded through any carbon or heteroatom off the ring system. Preferred groups include those of the following formula, which may be bonded through any atom of the ring system:



wherein  $r$  is 0 or 1 and  $T$  is  $-\text{O}-$ ,  $-\text{S}-$ ,  $-\text{N}-\text{R}^8$  or  $-\text{CH}-\text{R}^8$  where  $\text{R}^8$  is hydrogen, alkyl, aryl or arylalkyl. Exemplary heterocyclo groups include the following: thienyl, furyl, pyrrolyl, pyridyl, imidazolyl, pyrrolidinyl, piperidinyl, azepinyl, indolyl, isoindolyl, quinoliny, isoquinoliny, benzothiazolyl, benzoxazolyl, benzimidazolyl, morpholiny, piperazinyl, 4-alkylpiperazinyl, 4-alkylpiperidinyl, 3-alkpyrrolidinyl, oxazolyl, pyrazolyl, thiophenyl, pyridazinyl, thiazolyl, triazolyl, pyrimidinyl, 1,4-dioxanyl, benzoxadiazolyl, and benzofurazanyl. Exemplary substituents include one or more alkyl groups as described above and/or one or more groups described above as alkyl substituents.

The terms "halogen" or "halo" as used herein alone or as part of another group, denote chlorine, bromine, fluorine and iodine.

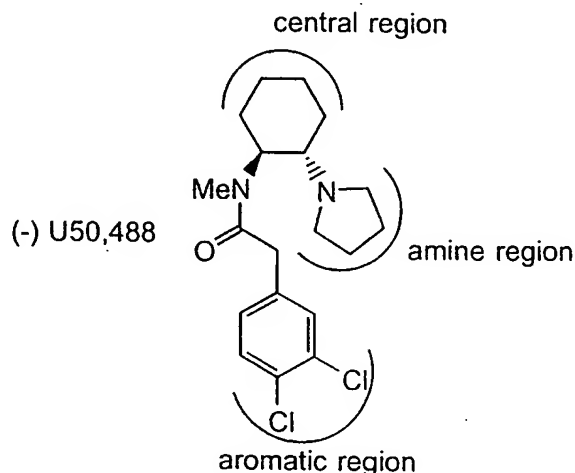
The term "acyl", as used herein alone or as part of another group, denotes the moiety formed by removal of the hydroxyl group from the group  $-\text{COOH}$  of an organic carboxylic acid. Exemplary groups include alkylcarbonyl, arylcarbonyl, or carbocyclo- or

heterocyclocarbonyl. The term "acyloxy", as used herein alone or as part of another group denotes an acyl group as described above bonded through an oxygen linkage (-O-).

### DETAILED DESCRIPTION OF THE INVENTION

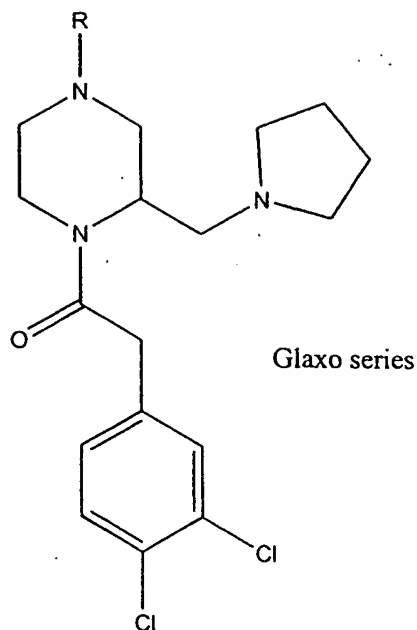
Peripherally-acting  $\kappa$  agonists can be prepared by the attachment of polar groups to non-peptide  $\kappa$  opioid receptor selective agonists, such as the arylacetamides. In designing the peripherally-acting ligands, the introduction of the polar groups may result in either retention or enhancement of antinociceptive potency and selectivity and also may increase the polarity of the ligand sufficient to reduce or eliminate CNS penetration across the blood-brain barrier (BBB). Thus, the identity and the positioning of the polar group(s) are important.

Using the prototypic arylacetamide, U50,488, as an example, the arylacetamide pharmacophore can be divided into three regions: the aromatic region, the central region, and the amine region. All three regions represent potential positions for the attachment of polar groups.



20 Compounds of formula (I) of the present invention are made as follows.

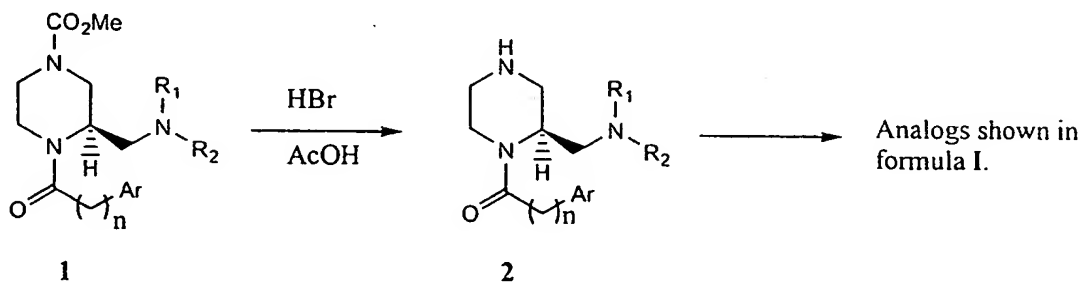
A series of novel compounds were made based on the class of arylacetamides reported by Glaxo (J. Med. Chem. 1993, 36, 2075). Specifically, compound 1 can be deprotected to yield intermediate 2, which can be derivatized by the attachment of a variety of polar groups (Scheme 1).



The 3'-substituted series can be prepared via **Scheme 2**. The reduction of the Schiff base intermediate formed during the cyclization to **6** is expected to be stereoselective due to the directing effect of the neighboring hydroxymethyl group. Both intermediates **11** and **12** can be derivatized to confer peripheral selectivity.

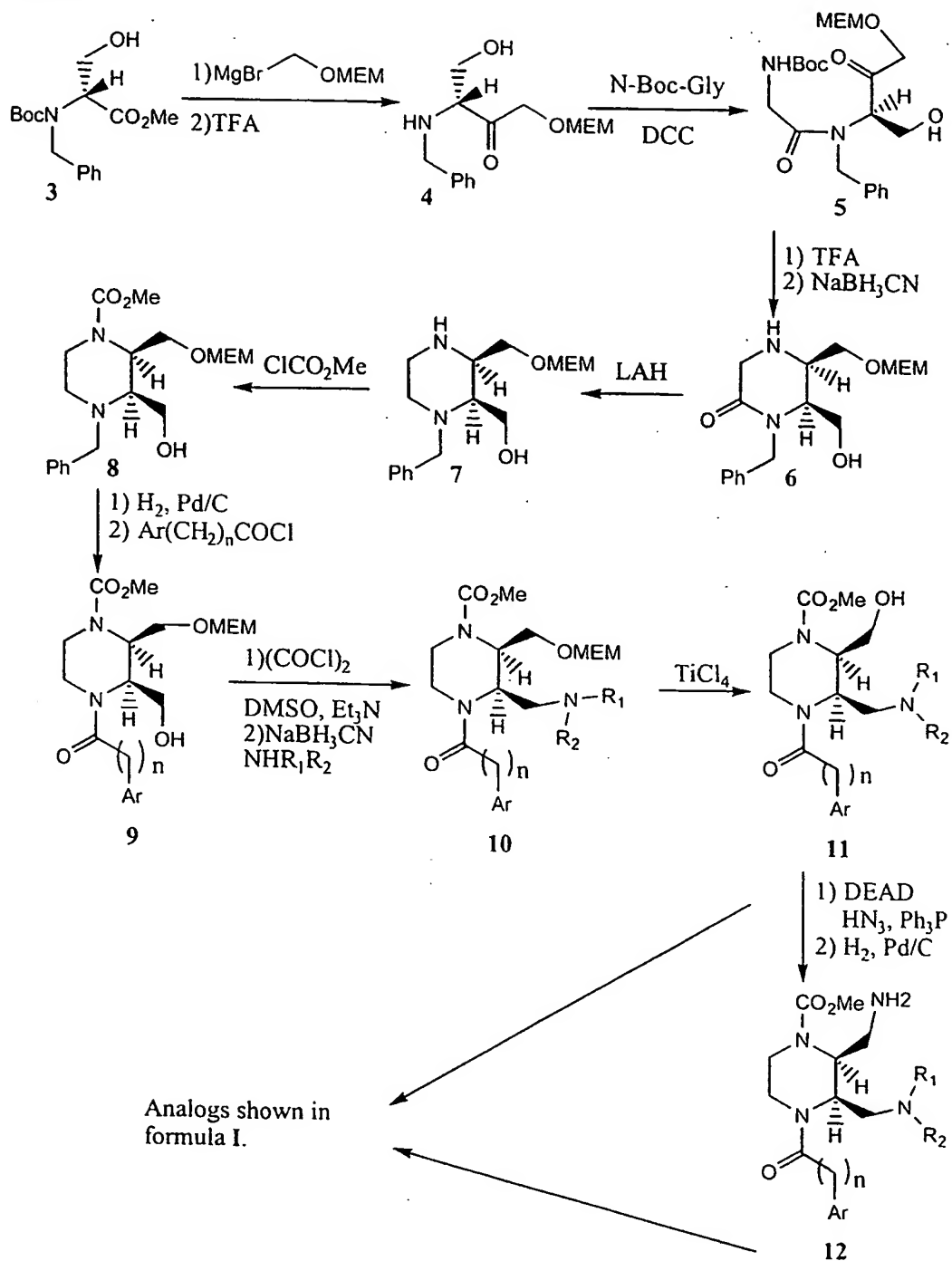
The 5'-substituted series can be prepared via **Schemes 3** and **4**. Starting from N-t-Boc-O-MEM-D-serine, the 5'-(S) series can be prepared, and starting from N-t-Boc-O-MEM-L-serine allows the preparation of the 5'-(R) series.

#### Scheme 1



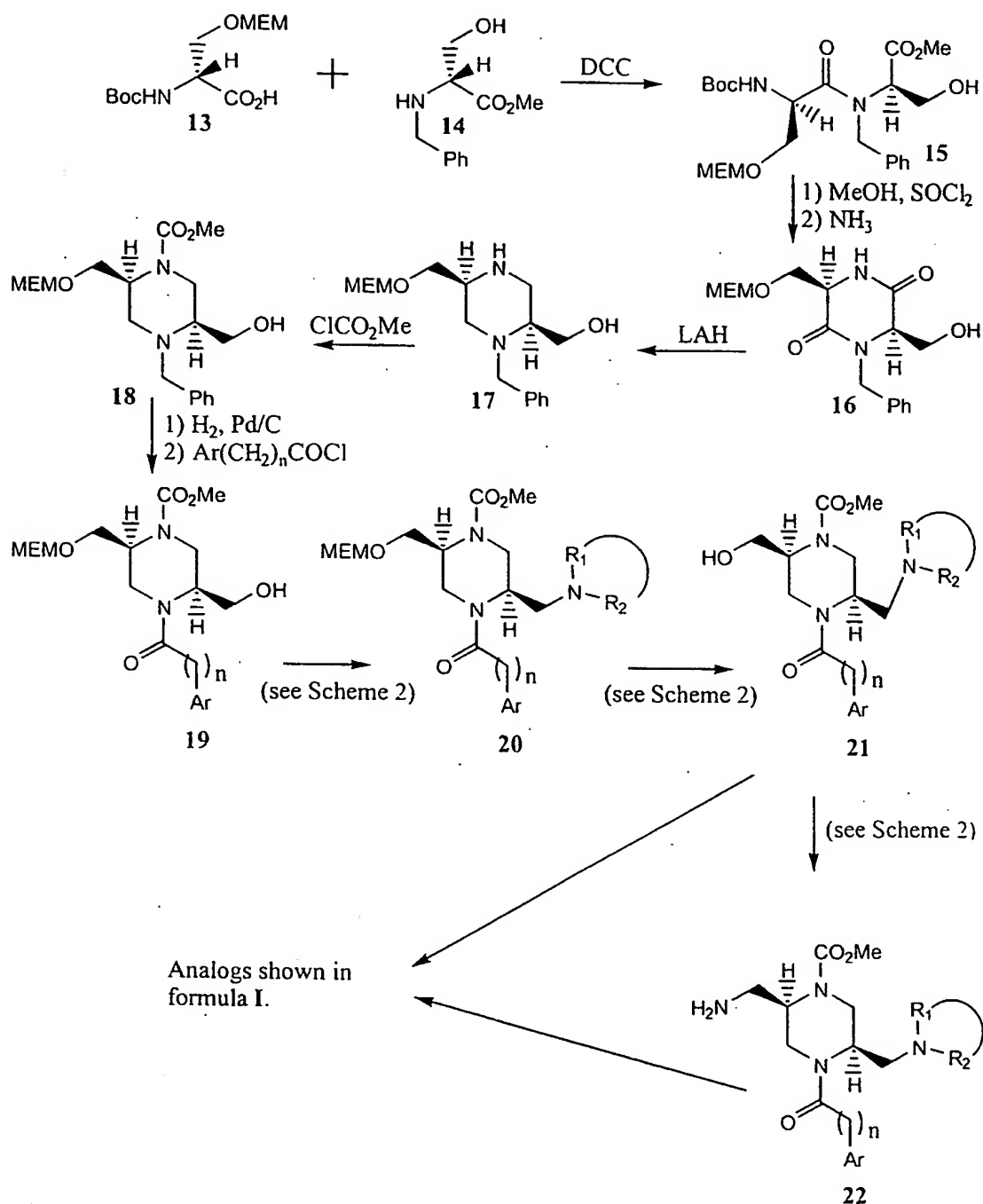
wherein Ar, R<sub>1</sub>, R<sub>2</sub>, and n are defined in formula I.

Scheme 2.



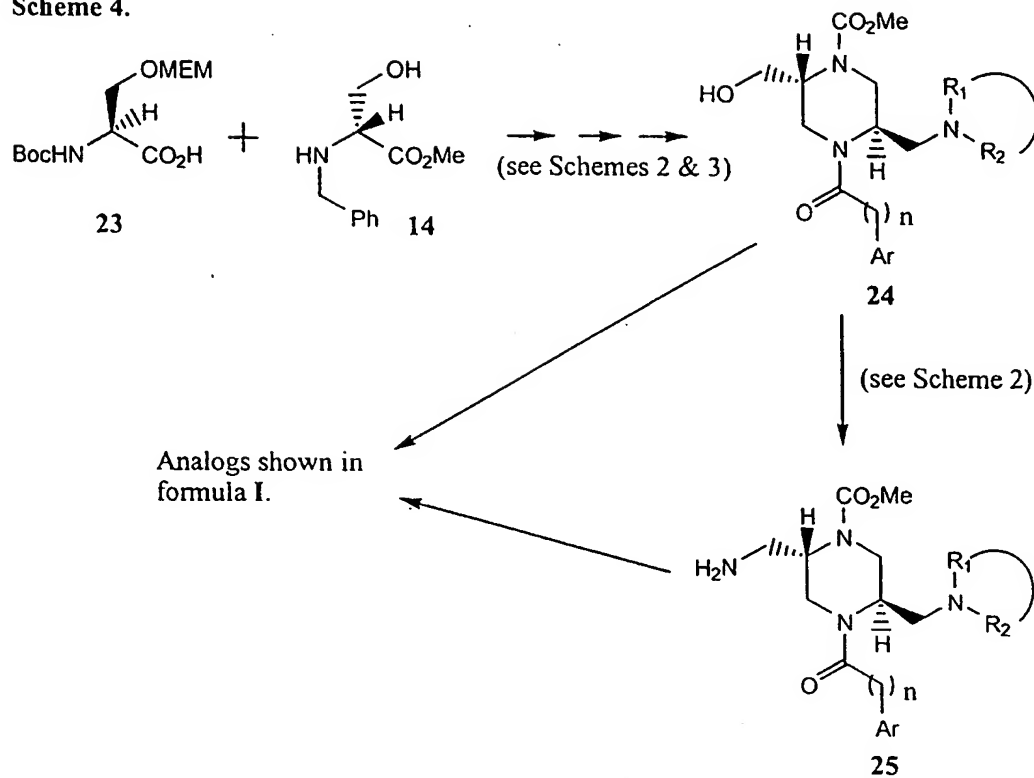
wherein Ar, R<sub>1</sub>, R<sub>2</sub>, and n are as defined in formula I.

Scheme 3.



wherein Ar, R<sub>1</sub>, R<sub>2</sub>, and n are as defined in formula I.

Scheme 4.



wherein Ar, R<sub>1</sub>, R<sub>2</sub>, and n are as defined in formula I.



Using Schemes 1-4 the following example compounds are made.

- 5 -Intermediate 3 can be treated with t-butyl bromoacetate and deprotected to produce  
{4-[1-(3,4-Dichlorophenyl)acetyl-2R-(1-pyrrolidinyl)-methyl]piperazinyl}acetic acid (26).
- Intermediate 3 can be reacted with methane sulfonyl chloride to produce  
[1-(3,4-Dichlorophenyl)acetyl-4-methanesulfonyl-2R-(1-pyrrolidinyl)methyl]piperazine (27).
- 10 -Intermediate 3 can be coupled to N-t-Boc-L-aspartic acid-b-benzyl ester and deprotected to  
produce [4-S-Aspartic acid-a-amido-1-(3,4-dichlorophenyl)acetyl-2R-(1-  
pyrrolidinyl)methyl]piperazine (28).
- 15 -Intermediate 11 can be treated with t-butyl bromoacetate and deprotected to produce  
Methyl-[2R-(O-2-acetic acid)hydroxymethyl-4-(3,4-dichlorophenyl)acetyl-3R-(1-  
pyrrolidinyl)methyl]-1-piperazinecarboxylate (29).
- Intermediate 11 can be coupled to to N-t-Boc-L-aspartic acid-b-benzyl ester and deprotected  
to produce Methyl-[2R-(O-S-aspartic acid-a-acetyl)hydroxymethyl-4-(3,4-  
20 dichlorophenyl)acetyl-3R-(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate (30).
- Intermediate 12 can be treated with methanesulfonyl chloride to produce  
Methyl-[4-(3,4-dichlorophenyl)acetyl-2R-(N-methanesulfonamido)aminomethyl-3R-(1-  
pyrrolidinyl)methyl]-1-piperazinecarboxylate (31).
- 25 -Intermediate 12 can be coupled to 2S-isothiocyanato-succinic acid-dibenzyl ester and  
deprotected to yield Methyl-{4-[3,4-dichlorophenyl]acetyl-3R-[1-pyrrolidinyl]methyl-2R-[N-  
(succinic acid-2S-thioureido)]aminomethyl}-1-piperazinecarboxylate (32).
- Intermediate 21 can be treated with t-butyl bromoacetate and deprotected to produce  
30 Methyl-[2S-(O-2-acetic acid)hydroxymethyl-4-(3,4-dichlorophenyl)acetyl-5R-(1-  
pyrrolidinyl)methyl]-1-piperazinecarboxylate (33).
- Intermediate 21 can be coupled to to N-t-Boc-L-aspartic acid-b-benzyl ester and deprotected  
to produce Methyl-[2S-(O-S-aspartic acid-a-acetyl)hydroxymethyl-4-(3,4-  
35 dichlorophenyl)acetyl-5R-(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate (34).
- Intermediate 22 can be treated with methanesulfonyl chloride to produce

Methyl-[4-(3,4-dichlorophenyl)acetyl-2S-(N-methanesulfonamido)aminomethyl-5R-(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate (35).

5 -Intermediate 22 can be coupled to 2S-isothiocyanato-succinic acid-dibenzyl ester and deprotected to yield Methyl-{4-[3,4-dichlorophenyl]acetyl-5R-[1-pyrrolidinyl)methyl-2S-[N-(succinic acid-2S-thioureido)]aminomethyl}-1-piperazinecarboxylate (36).

-The 2R isomers of 33-34 and 35-36 can be prepared from intermediates 24 and 25, respectively to produce

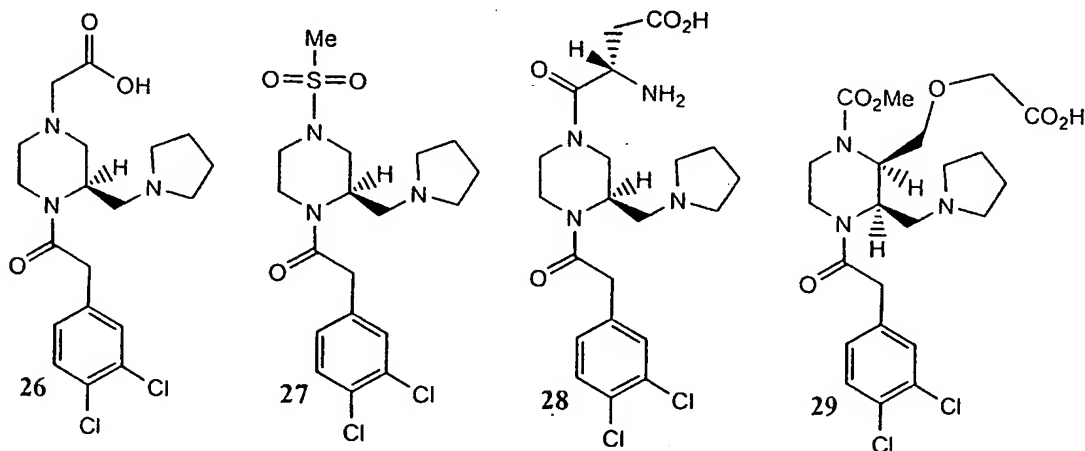
10 Methyl-[2R-(O-2-acetic acid)hydroxymethyl-4-(3,4-dichlorophenyl)acetyl-5R-(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate (37).

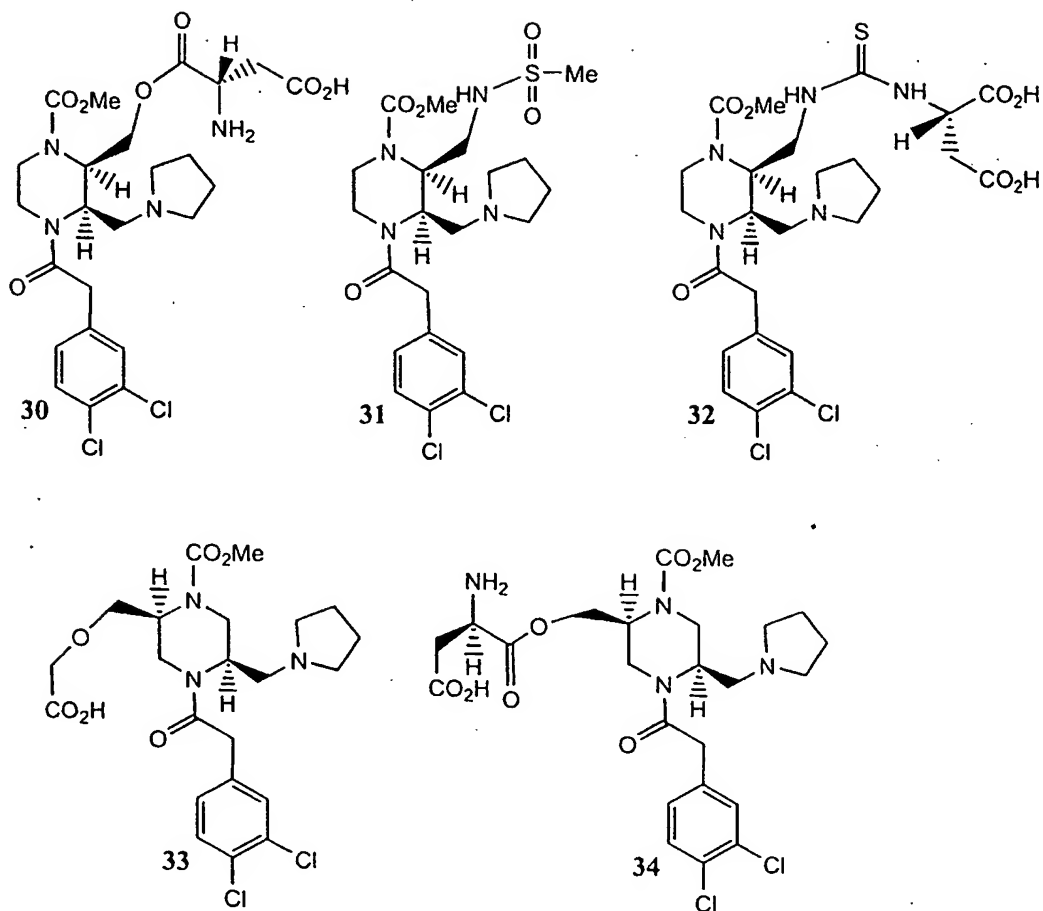
Methyl-[2R-(O-S-aspartic acid-a-acetyl)hydroxymethyl-4-(3,4-dichlorophenyl)acetyl-5R-(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate (38).

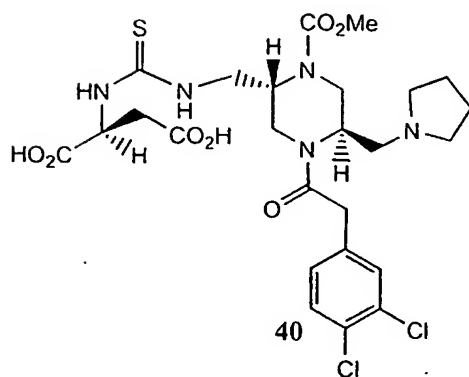
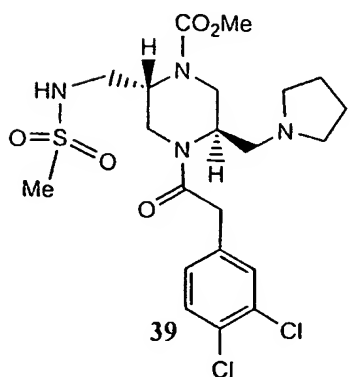
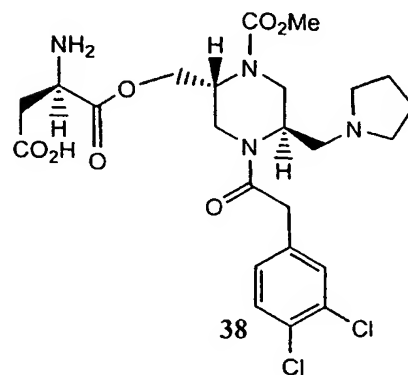
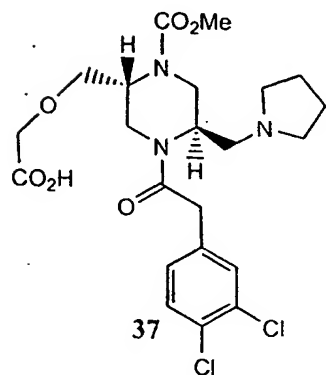
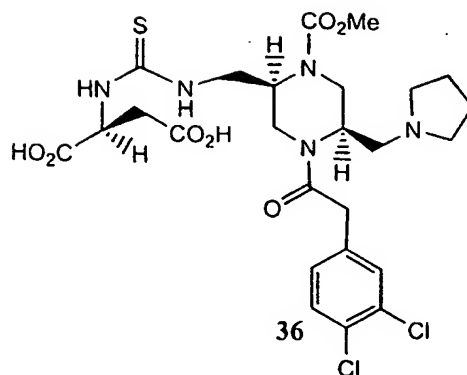
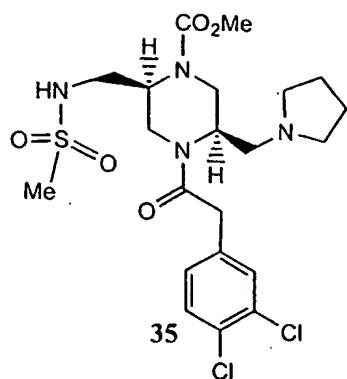
15 Methyl-[4-(3,4-dichlorophenyl)acetyl-2R-(N-methanesulfonamido)aminomethyl-5R-(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate (39).

Methyl-{4-[3,4-dichlorophenyl]acetyl-5R-[1-pyrrolidinyl)methyl-2R-[N-(succinic acid-2S-thioureido)]aminomethyl}-1-piperazinecarboxylate (40).

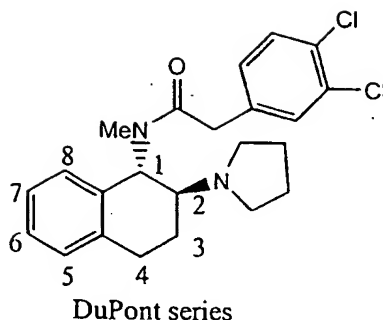
20 The corresponding structural formulas are shown hereunder.







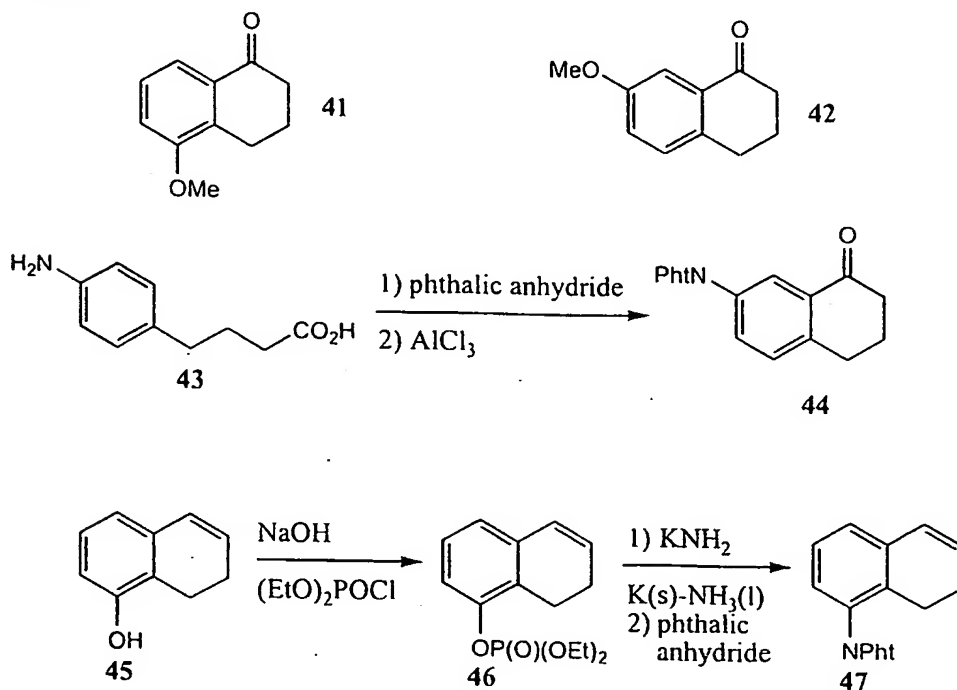
Compounds of formula II of the present invention are made by peripheralization by  
 5 substitutions of the benzo portion of the tetrahydronaphthyl ring of DuPont series of  
 compounds with polar groups.



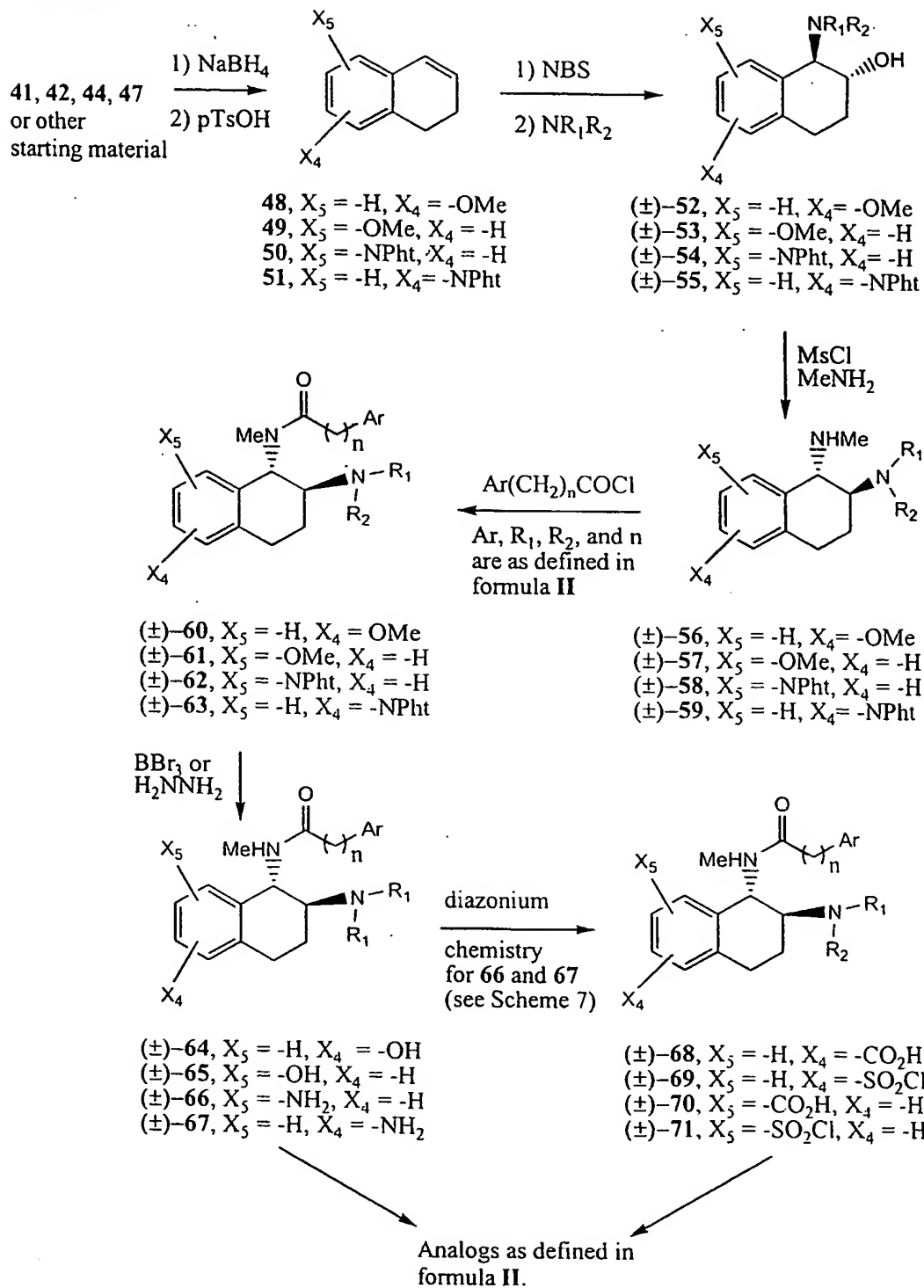
Starting material or precursors of the starting material are commercially available and thus allows regiospecific substitutions of the tetrahydronaphthyl ring (Scheme 5). While 5-hydroxytetralone, 6-hydroxytetralone, 7-hydroxytetralone, and 7-aminotetralone derivatives are readily available, 5-aminotetralone could be prepared from 5-hydroxytetralone (J. Org. Chem. 1972, 37, 3570).

The tetralone derivatives can be converted to dihydronaphthyl derivatives and subjected to chemistry similar to that employed in the preparation of U50,488 derivatives. The resulting compounds are racemic mixtures that can be derivatized to confer peripheral selectivity. If necessary, the final compounds or one of the intermediates can be resolved to test both enantiomers.

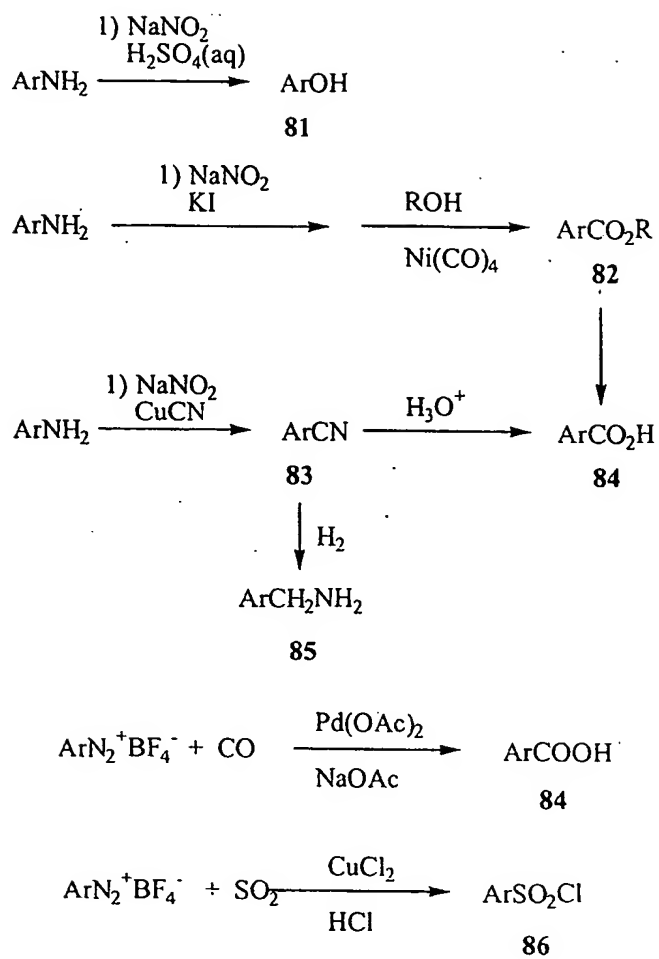
Scheme 5.



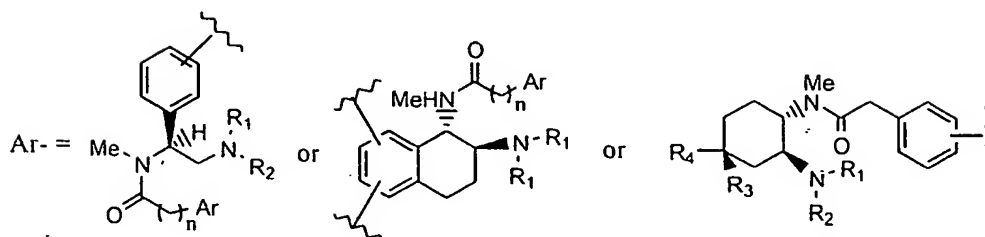
Scheme 6.



Scheme 7.



81, 82, 84, 85, 86  $\longrightarrow$  Analogs shown in formulas II-IV



wherein  $R_1$ ,  $R_2$ , and  $n$  are as defined in formula I.

Following the procedure shown in Schemes 5-7, the following example compounds are prepared.

5 -Intermediate (±)-64 can be treated with t-butyl bromoacetate and deprotected to produce (±)-2-(3,4-dichlorophenyl)-N-methyl-N-1-[1,2,3,4-tetrahydro-5-(O-2-acetic acid)-hydroxy-2-(1-pyrrolidinyl)naphthyl]acetamide (72).

10 -Intermediate (±)-65 can be treated with t-butyl bromoacetate and deprotected to produce (±)-2-(3,4-dichlorophenyl)-N-methyl-N-1-[1,2,3,4-tetrahydro-7-(O-2-acetic acid)-hydroxy-2-(1-pyrrolidinyl)naphthyl]acetamide (73).

15 -Intermediate (±)-66 can be treated with methanesulfonyl chloride to produce (±)-2-(3,4-dichlorophenyl)-N-methyl-N-1-[1,2,3,4-tetrahydro-7-(N-methanesulfonamido)-amino-2-(1-pyrrolidinyl)naphthyl]acetamide (74).

-Intermediate (±)-67 can be treated with methanesulfonyl chloride to produce (±)-2-(3,4-dichlorophenyl)-N-methyl-N-1-[1,2,3,4-tetrahydro-5-(N-methanesulfonamido)-amino-2-(1-pyrrolidinyl)naphthyl]acetamide (75).

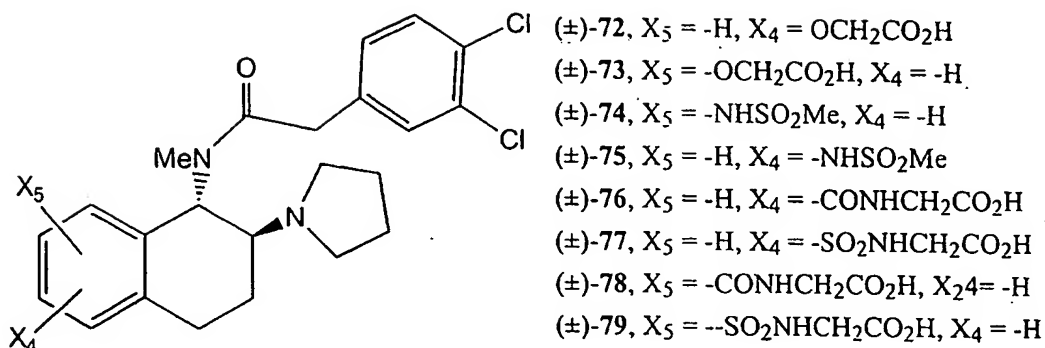
20 -Intermediate (±)-68 can be treated with glycine benzyl ester and deprotected to produce (±)-2-(3,4-dichlorophenyl)-N-methyl-N-1-[1,2,3,4-tetrahydro-5-(N-2-acetic acid)-carboxamido-2-(1-pyrrolidinyl)naphthyl]acetamide (76).

25 -Intermediate (±)-69 can be treated with glycine benzyl ester and deprotected to produce (±)-2-(3,4-dichlorophenyl)-N-methyl-N-1-[1,2,3,4-tetrahydro-5-(N-2-acetic acid)-sulfonamido-2-(1-pyrrolidinyl)naphthyl]acetamide (77).

30 -Intermediate (±)-70 can be treated with glycine benzyl ester and deprotected to produce (±)-2-(3,4-dichlorophenyl)-N-methyl-N-1-[1,2,3,4-tetrahydro-7-(N-2-acetic acid)-carboxamido-2-(1-pyrrolidinyl)naphthyl]acetamide (78).

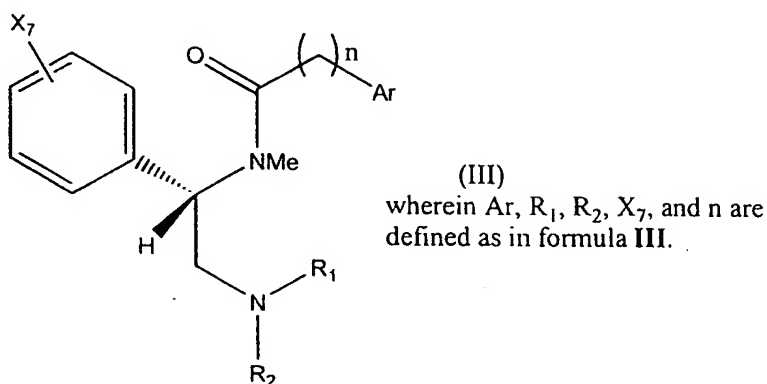
35 -Intermediate (±)-71 can be treated with glycine benzyl ester and deprotected to produce (±)-2-(3,4-dichlorophenyl)-N-methyl-N-1-[1,2,3,4-tetrahydro-7-(N-2-acetic acid)-sulfonamido-2-(1-pyrrolidinyl)naphthyl]acetamide (79).





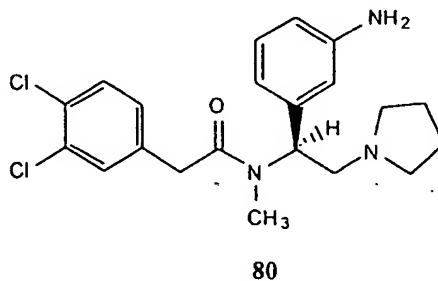
The compounds of formula III of the present invention are prepared by substituting the central phenyl ring with polar groups.

5



Compound 80 and analogues undergo a variety of diazonium-involving reactions for the attachment of polar groups (Scheme 7).

10



Using the procedure shown in Scheme 7, the following compounds are made.

15

-Intermediate 81 can be treated with dibenzyl phosphoryl chloride followed by deprotection to produce 2-(3,4-dichlorophenyl)-N-methyl-N-{1-3-(O-phosphoryl)hydroxyphenyl-2-(1-pyrrolidinyl)ethyl}acetamide (87).

5

-Intermediate 85 can be coupled to methanesulfonyl chloride to produce 2-(3,4-dichlorophenyl)-N-methyl-N-{1-[3-(N-methanesulfonamido)aminomethyl]phenyl-2-(1-pyrrolidinyl)ethyl}acetamide (88).

10 -Intermediate 85 can be coupled to 2S-isothiocyanato succinic acid and deprotected to produce

2-(3,4-dichlorophenyl)-N-methyl-N-{1-[3-(N-succinic acid-2S-thioureido)aminomethyl]phenyl-2-(1-pyrrolidinyl)ethyl}acetamide (89).

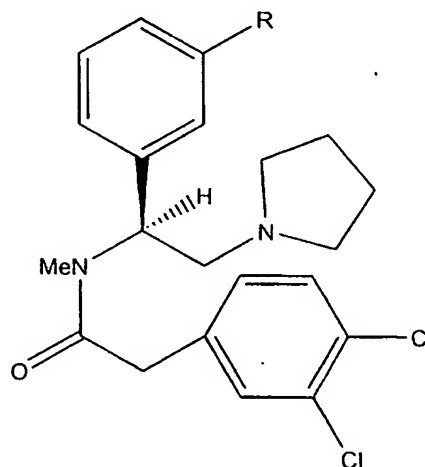
15 -Intermediate 80 can be treated with dibenzyl phosphoryl chloride followed by deprotection to produce 2-(3,4-dichlorophenyl)-N-methyl-N-{1-3-(N-phosphoramido)aminophenyl-2-(1-pyrrolidinyl)ethyl}acetamide (90).

87, R = -OPO<sub>3</sub>H<sub>2</sub>

88, R = -CH<sub>2</sub>NHSO<sub>2</sub>Me

89, R = (S) -CH<sub>2</sub>NHC(S)NHCH(CO<sub>2</sub>H)CH<sub>2</sub>CO<sub>2</sub>H

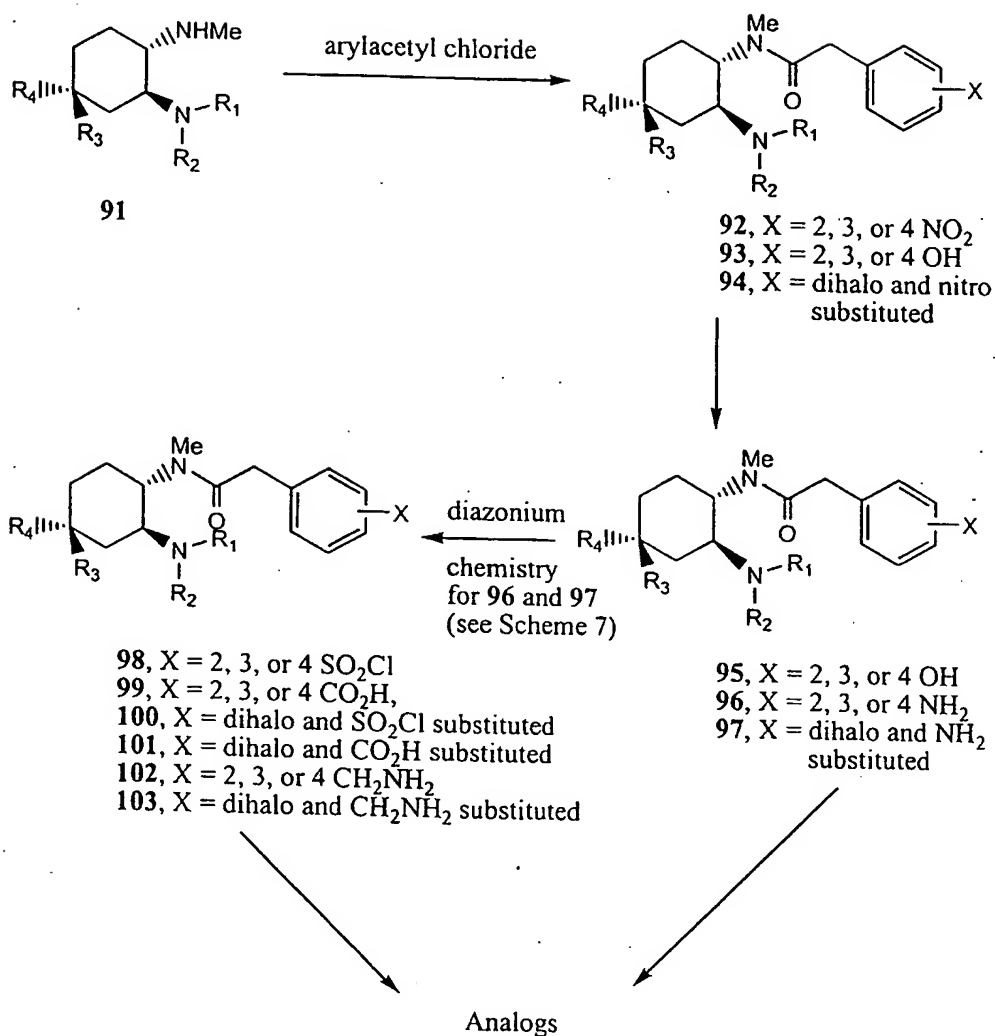
90, R = -NHPO<sub>3</sub>H<sub>2</sub>



20

The compounds of formula IV may be prepared by Scheme 8.

Scheme 8.



wherein R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, and R<sub>4</sub> are defined in formulas III and IV.

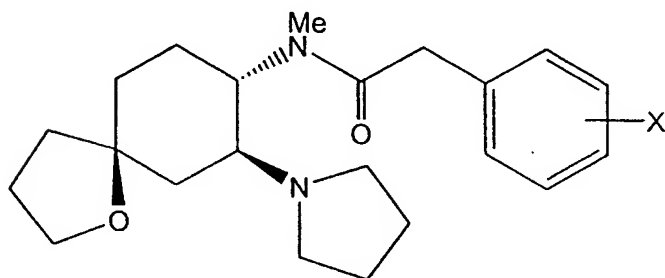
The diamino intermediate 91 (J. Med. Chem. 1990, 33, 286) can be coupled to different regioisomers of nitrophenylacetic acid, which are all commercially available. Reduction of the nitro group provides an amino group for the attachment of polar groups. Alternatively, the amino intermediates 95-97 readily undergo diazonium chemistry that converts the amino groups to carboxyl and sulfonyl chloride groups. This allows the polar groups to be attached via different linkers.

Following the procedure in Scheme 8, the following compounds are made.

-Intermediate 96 can be treated with : ethanesulfonyl chloride to produce  
(-)-(5a,7a,8b)-N-methyl-N-[7-(1-pyrrolidinyl)-1-oxaspiro-[4,5]dec-8-yl]-3-(N-methanesulfonamido)aminophenylacetamide (104).

-Intermediate 98 can be coupled to glycine benzyl ester and deprotected to yield  
(-)-(5a,7a,8b)-N-methyl-N-[7-(1-pyrrolidinyl)-1-oxaspiro-[4,5]dec-8-yl]-3-(N-2-acetic acid)sulfonamidophenylacetamide (105).

-Intermediate 99 can be coupled to glycine benzyl ester and deprotected to yield  
(-)-(5a,7a,8b)-N-methyl-N-[7-(1-pyrrolidinyl)-1-oxaspiro-[4,5]dec-8-yl]-3-(N-2-acetic acid)carboxamidophenylacetamide (106).



104, X = NHSO<sub>2</sub>CH<sub>3</sub>,  
105, X = SO<sub>2</sub>NHCH<sub>2</sub>CO<sub>2</sub>H  
106, X = CONHCH<sub>2</sub>CO<sub>2</sub>H

Compounds of the above formulas may have one or more asymmetric carbon atoms. Pure stereochemically isomeric forms of the above compounds may be obtained, and diastereoisomers isolated by physical separation methods, including, but not limited to crystallization and chromatographic methods. Cis and trans diastereomeric racemates may be further resolved into their isomers. If separated, active isomers may be identified by their activity. Such purification is not, however, necessary for preparation of the compositions or practice of the methods herein.

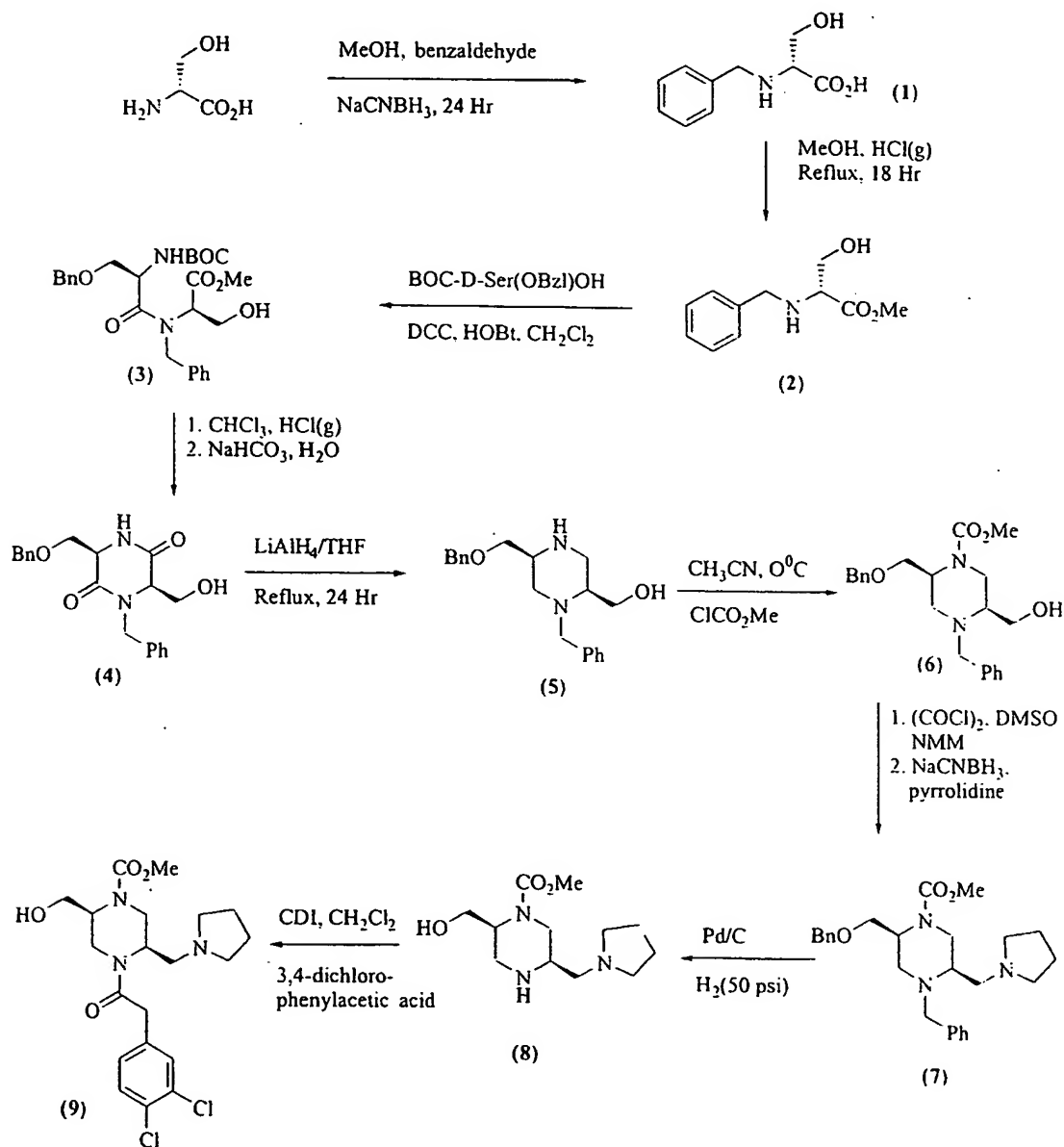
As used herein, the compounds provided herein also include pharmaceutically acceptable salts, acids and esters thereof, stereoisomers, and also metabolites or prodrugs thereof that possess activity as analgesics but do not cause substantial CNS effects when administered or applied. Metabolites include any compound that is produced upon administration of the compound and metabolism thereof.

More detailed preparations of the compounds of the present invention follow.

### Compounds of Formula I

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Preparatory for the compounds of formula I, the following intermediates were prepared.



10

N-Benzyl-D-serine(1)<sup>1</sup>: To a mixture of D-serine (25.0 g, 0.237 mol) and 200 mL anhydrous methanol was added sodium cyanoborohydride (11.95 g, 0.190 mol), while maintaining the temperature at 0°C with an ice bath. Then, benzaldehyde (26.5 mL, 0.261 mol) was added to the reaction flask, dropwise, at 30°C. The mixture was stirred for 60 Hr. at room temperature. Then, the mixture was filtered and rinsed with methanol (50 mL). The white solid was dried in a vacuum oven at 40°C and 10 mmHg over 2 nights: 24.5 g. The filtrate was retained and the solvent was evaporated. This oil was passed through a silica gel column (10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) and 3.4 g of the desired compound was isolated. The total amount of the product was 27.9g (60.0 % yield). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 3.25 (m, 1H, CH), 3.85 (m, 2H, CH<sub>2</sub>), 4.11 (d, 2H, benzylic CH<sub>2</sub>), 7.45-7.53 (m, 5H, ArH).

Ref.

(1) Ohfuné, Y.; Kurokawa, N.; Higuichi, N.; Saito, M.; Hashimoto, M.; Tanaka, T. An efficient one-step reductive N-monoalkylation of α-amino acids. *Chemistry Letters*. 1984, 441-444.

N-Benzyl-D-serine methyl ester(2): Hydrogen chloride (gas) was bubbled into anhydrous methanol for 10 minutes. Then, the solution was allowed to cool to room temperature. Then, N-benzyl-D-serine (24.6 gm, 0.126 mol) was added to the reaction flask and refluxed over night under dry nitrogen. Then, the solvent was evaporated and dissolved in dichloromethane (200 mL), and washed with a saturated solution of sodium bicarbonate. The dichloromethane layer was dried with magnesium sulfate and the solvent was evaporated. (23 gm, 87.2 % yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 3.41 (d, 1H, CH), 3.52-3.80 (dd, 2H, benzylic ), 3.69 (s, 3H, OMe), 7.27 (s, 5H, ArH).

N-[(1,1-Dimethylethoxy)carbonyl-D-Ser-(O-Bzl)-N-benzyl-D-Ser-OMe (3): To a solution of N-boc-D-serine-(O-bzl)OH (15 g, 50.76 mmol) in anhydrous dichloromethane (200 mL) was added HOBt (7.54 g, 55.8 mmol) at 0°C under dry nitrogen. Then, DCC (11.5 g, 55.7 mmol) in dichloromethane (100 mL) was added dropwise to the reaction flask. Then, this mixture was stirred for 1 Hr. Then, N-benzyl-D-serine-OMe (10 g, 47.8 mmol) in dichloromethane (100 mL) was added dropwise to the reaction flask. Then, stirred for 4 days. Then, filtered and rinsed with dichloromethane (100ml). The white precipitate was DCU and HOBt. The filtrate was evaporated and re-dissolved in ethyl acetate (100 mL). Then, this was allowed to precipitate, overnight - more DCU. This was filtered and rinsed with ethyl acetate. Then, this was isolated on a silica gel column (20% ethyl acetate/ hexanes): an oil- 17.3g, 74.3% yield. <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 1.43 (s, 9H, t-Bu), 3.54 (t, 1H, OH), 3.72 (s, 3H, OMe), 3.75 (dd, 2H, CH<sub>2</sub>), 3.79 (dd, 2H, CH<sub>2</sub>), 4.41 (d, 2H, CH<sub>2</sub> benzylic), 4.43 (d, 2H, CH<sub>2</sub> benzylic), 7.27-7.30(m, 10H, ArH).

(2R,5R)-2-((Benzyloxy)methyl)-5-(Hydroxymethyl)-4-(phenylmethyl)-3,6-piperazine dione(4)<sup>2</sup>:

Into anhydrous chloroform (300 mL) was bubbled hydrogen chloride (gas). Then, the dipeptide (3) (13.5 g, 27.7 mmol) in chloroform (100 ml) was added to the reaction flask. The flask was stoppered and stirred for 64 Hr. Then, a saturated solution (100 ml) of sodium bicarbonate was added and stirred vigorously for 48 Hr. The cyclization was completed at

this point. The organic layer was separated from the aqueous layer in a 1L separatory funnel. The product was isolated from a silica gel column, eluting with dichloromethane-methanol-0.88 ammonia (96:2:2) to give (4) as an amorphous solid (6.0 g, 61.1% yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 3.72-3.96 (m, 7H), 3.97-5.24 (dd, 2H, CH<sub>2</sub> benzylic), 4.45 (dd, 2H, CH<sub>2</sub> benzylic), 7.15-7.30 (m, 10H, ArH); MS (FAB) m/e 355 (MH<sup>+</sup>).

Ref.

(2) Williams, T. M.; Ciccarone, T. M.; MacTough, S. C. and et al. 2-Substituted piperazines as constrained amino acids. *J. Med. Chem.* 1996, 39, 1345-1348.

(2S,5S)-2-((Benzyloxy)methyl)-4-(phenylmethyl)-5-piperazinemethanol(5): A suspension of lithium aluminum hydride (0.9 g, 23.7 mmol) in anhydrous tetrahydrofuran (40 mL) was treated with a solution of piperazinedione 4 (2.1 g, 5.92 mmol) in anhydrous tetrahydrofuran (200 mL). The reaction mixture was heated at reflux for 24 Hr and then, stirred at room temperature for 12 Hr. Water (10 mL) was added followed by aqueous sodium hydroxide (1N, 10 mL) and water (10 mL). The mixture was filtered, and the filtrate was evaporated to give 5 (1.67 g, 86.4% yield) as a viscous oil. <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 2.58 (dd, 2H, CH<sub>2</sub>), 2.61 (t, 1H, OH), 3.10 (dd, 2H, CH<sub>2</sub>), 3.25 (dd, 2H, CH<sub>2</sub>), 3.50 (dd, 2H, CH<sub>2</sub>), 3.74 (s, 2H, CH<sub>2</sub>), 4.41 (dd, 2H, CH<sub>2</sub> benzylic), 7.20-7.30 (m, 10H, ArH).

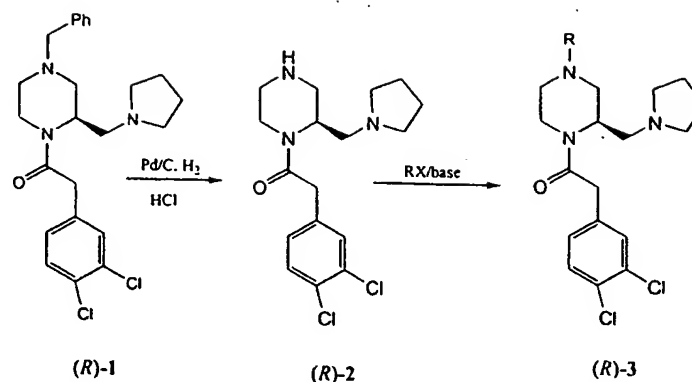
(2S,5S)-Methyl 2-[(Benzyloxy)methyl]-5-(hydroxymethyl)-4-(phenylmethyl)-1-piperazine carboxylate (6)<sup>3</sup>: A solution of 5 (1.67 g, 5.11 mmol) in acetonitrile (20 mL) was treated with a solution of methyl chloroformate (0.532 g, 5.63 mmol) in acetonitrile (10 mL) at 0°C. The mixture was stirred at ambient temperature for 30 min., and then aqueous sodium carbonate solution (15 mL) was added. The organic solvent was removed, and the aqueous residue was extracted with chloroform (3x10 mL). The combined organic extracts were washed with aqueous sodium carbonate solution (10 mL), dried, and evaporated to give 6 (1.52 g, 77.3% yield) as an oil. <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 2.54 (dd, 2H, CH<sub>2</sub>), 2.45 (t, 1H, OH), 2.72 (dd, 2H, CH<sub>2</sub>), 3.51 (dd, 2H, CH<sub>2</sub>), 3.67 (dd, 2H, CH<sub>2</sub>), 3.69 (s, 3H, OMe), 3.81 (dd, 2H, CH<sub>2</sub>), 4.44 (dd, 2H, CH<sub>2</sub> benzylic), 7.17-7.31 (10H, ArH).

(2S,5S)-Methyl 2-[(Benzyloxy)methyl]-5-[(1-pyrrolidinyl)methyl]-4-(phenylmethyl)-1-piperazinecarboxylate(7)<sup>3</sup>: A solution of oxalyl chloride (0.545 mL, 6.24 mmol) in dichloromethane (10 mL) at -65°C was treated with a solution of dimethyl sulfoxide (1.14 mL, 16.0 mmol) in dichloromethane (5 mL) maintaining the reaction temperature below -65°C. The mixture was stirred at -70 °C for 10 min, and then a solution of the piperazinemethanol (6: 2 g, 5.19 mmol) in dichloromethane (20 mL) was added at such a rate that the reaction temperature was maintained below -65°C. The reaction mixture was stirred at -65°C for 3 Hr, and a solution of N-methylmorpholine (1.42 mL, 12.91 mmol) in dichloromethane (5 mL) was added. The mixture was stirred at -20 °C for 45 min and then washed with ice-cold hydrochloric acid (0.01 N, 100mL and 50mL), dried, evaporated, and placed on a high vacuum pump overnight. The residue was dissolved in methanol (10 mL) and was added to a solution of pyrrolidine (0.91 mL, 10.94 mmol) in methanol (10 mL) at -10 °C, which had been adjusted to pH 6.0 by the addition of methanolic hydrogen chloride. Sodium cyanoborohydride (0.67 g, 10.66 mmol) and 4-Å molecular sieves (0.66 g) were

- added, and the mixture was stirred at ambient temperature for 18 Hr. The mixture was filtered, and the filtrate was evaporated to dryness. The residue was dissolved in aqueous sodium carbonate (1M, 25mL) and extracted with dichloromethane (2x50 mL). The product was isolated from a silica gel column, eluting with dichloromethane-methanol (98:2) to give
- 5 (7: 1.0 g, 23.0 % yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 1.75 (m, 4H, CH<sub>2</sub>CH<sub>2</sub>), 2.46 (m, 3H), 2.48 (m, 4H, CH<sub>2</sub>CH<sub>2</sub>), 2.55 (dd, 2H, CH<sub>2</sub>), 2.70-2.85 (m, 3H), 3.41 (dd, 2H, CH<sub>2</sub>), 3.69 (s, 3H, OMe), 4.10 (m, 1H), 4.20 (m, 1H), 4.41 (dd, 2H, CH<sub>2</sub> benzylic), 7.10-7.31 (m, 10H, ArH); MS (FAB) m/e 438 (MH<sup>+</sup>).
- 10 (3) Naylor, A.; Judd, D. B.; Lloyd, J. E.; Scopes, D. I. C.; Hayes, A. G.; Birch, P. J. A potent new class of k-Receptor agonist: 4-substituted 1-(arylacetyl)-2-[(dialkylamino)methyl] piperazines. *J. Med. Chem.* 1993, 36, 2075-2083.
- 15 (2S,5S)-Methyl 2-(Hydroxymethyl)-5-[(1-pyrrolidinyl)methyl]-1-piperazine carboxylate(8): A solution of 7 (0.25g, 0.571mmol) in ethanol (200 mL) was hydrogenated over 10% palladium on carbon (Degussa type E101 NE/W) at 50 psi for 7 days. Then, filtered through celite and filtrate was evaporated. (0.13 g, 0.5 mmol: 87% yield).
- 20 (2S,5S)-Methyl 4-[(3,4 - Dichlorophenyl)acetyl]-2-(hydroxy)methyl - 5-[(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate(9): To a solution of 1,1'-carbonyldiimidazole (0.20 g, 1.26 mmol) in dichloromethane (10 mL) was added portionwise 3,4-dichlorophenylacetic acid (0.25 g, 1.26 mmol) and the resulting solution stirred under nitrogen for 1 Hr, at room temperature. A solution of 8 (0.13g, 0.5 mmol) in dichloromethane (10 mL) was added and the mixture at room temperature for 18 Hr. The reaction mixture was washed with sodium carbonate solution (2 N, 2 x 10 mL), dried, and evaporated to give a viscous oil. This material was dissolved in a mixture of tetrahydrofuran (5 mL) and water (5 mL) and treated with lithium hydroxide (42 mg, 1.0 mmol). The reaction mixture was removed, and the aqueous residue was extracted with dichloromethane (3 x 10 mL). The combined organic extracts were dried and evaporated to give a colorless gum which was purified by flash column chromatography on silica gel, eluting with ethyl acetate-methanol (40:1) to give 9 (155 mg, 70 %) as a colorless foam.
- 35

Utilizing the above-denoted intermediates, the following compounds were prepared.



Chiral Compounds

5

Example 1

(R)-4-(Phenylmethyl)-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]piperazine hydrochloride [(R)-1 HCl]

ADL-01-0143-6

The compound (R)-1 HCl was prepared following the literature procedure<sup>3</sup> in 54% yield; mp 168-170°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.65 (4H, m), 1.95-3.00 (6H, m), 3.10-3.80 (9H, m), 4.35 (1H, m), 4.70 (1H, m), 7.00 (1H, m), 7.30 (7H, m); MS (FAB) 448 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>24</sub>H<sub>29</sub>Cl<sub>2</sub>N<sub>3</sub>O.2HCl.H<sub>2</sub>O: C, 53.64; H, 6.19; N, 7.82. Found: C, 53.69; H, 5.88; N, 7.49.

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Example 2

(R)-1-[(3,4-Dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]piperazine hydrochloride [(R)-2HCl]

ADL-01-0047-9

The compound was prepared by the catalytic hydrogenation of (R)-1 HCl following the procedure described in the above reference. The product was isolated as a free base as clear oil in 81% yield and the dihydrochloride salt was prepared from 1M etherial HCl; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.67 (4H, m), 1.95-3.10 (6H, m), 3.10-3.80 (7H, m), 4.30 (1H, m), 4.65 (1H, m), 7.05 (1H, m), 7.35 (3H, m); MS (FAB) 356 (M + H)<sup>+</sup>.

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Example 3

(R)-4-Methanesulfonyl-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]-piperazine hydrochloride [(R)-3a HCl]

ADL-01-0039-6

To the solution of (R)-2 (712 mg, 2mmol in 10 ml CH<sub>2</sub>Cl<sub>2</sub>), methanesulfonyl chloride (573 mg, 5 mmol) and pyridine (1ml) were added at 0 °C, stirred overnight at that temperature, the solution was washed with aq. 5% K<sub>2</sub>CO<sub>3</sub> solution, extracted with dichloromethane, dried and

evaporated solvent to give crude oil. This material was purified by flash column chromatography on silica gel, eluting with dichloromethane-methanol-ammonia (100:5:1), to give the free base, which was dissolved into 2 ml of dichloromethane and HCl (3 ml, 1 M in Et<sub>2</sub>O) was added to afford a white salt (*R*)-3a HCl (600 mg, 69%): mp 130-132 °C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.61-1.85 (4H, m), 2.38-2.65 (6H, m), 2.72 (3H, s), 2.80-3.06 (2H, m), 3.15-3.36 (1H, m), 3.50-3.96 (4H, m), 4.48-4.93 (1H, m), 7.00-7.10 (1H, m), 7.25-7.40 (2H, m); MS (FAB) 434 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>18</sub>H<sub>25</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>3</sub>S. HCl.0.5 CH<sub>3</sub>OH.: C, 45.64; H, 5.59; N, 8.63. Found: C, 45.69; H, 5.58; N, 8.73.

#### Example 4

##### (*R*)-4-t-Butyl-acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]-piperazine [(*R*)-3b]

ADL-01-0040-4

To the solution of (*R*)-2 (356 mg, 1 mmol in 10 ml acetone), t-butyl bromoacetate (234 mg, 1.2 mmol) and K<sub>2</sub>CO<sub>3</sub> (207 mg, 1.5 mmol) were added at 0 °C, stirred overnight at that temperature, the solution was washed with aq. 5% K<sub>2</sub>CO<sub>3</sub> solution, extracted with dichloromethane, dried and evaporated solvent to give crude oil. This material was purified by flash column chromatography on silica gel, eluting with dichloromethane-methanol-ammonia (100:5:1), to give (*R*)-3b (329 mg, 70%): <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.36 (9H, s), 1.91-2.37 (7H, m), 2.65-3.13 (7H, m), 3.58-4.20 (6H, m), 5.00 (1H, m), 7.12-7.21 (2H, m), 7.40 (1H, m). The compound was used directly into the following reaction.

#### Example 5

##### (*R*)-4-[(3,4-dichlorophenyl)acetyl]-3-[(1-pyrrolidinyl)methyl]-1-piperazineacetic acid dihydrochloride [(*R*)-3c 2HCl]

ADL-01-0042-0

Compound (*R*)-3b (329 mg, 0.7 mmol) was dissolved into 5 ml THF/Et<sub>2</sub>O (1:1), and HCl (5 ml, 1 M in Et<sub>2</sub>O) was added, kept 12hrs to afford a white salt (*R*)-3c HCl (275 mg, 61%): mp 190°C (d). <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.85-2.20 (4H, m), 2.95-4.41 (17H, m), 5.18-5.35 (1H, m), 7.30-7.45 (1H, m), 7.56-7.72 (2H, m); MS (FAB) 414 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>19</sub>H<sub>23</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>3</sub>. 2 HCl.0.5 H<sub>2</sub>O.: C, 45.16; H, 5.78; N, 8.32. Found: C, 44.91; H, 5.88; N, 8.56.

#### Example 6

##### (*R*)-4- N-t-Boc-D-aspartic acid-β-benzyl ester-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]-piperazine [(*R*)-3d]

ADL-01-0048-7

To the solution of N-t-Boc-D-aspartic acid-β-benzyl ester (646mg, 2 mmol) and HOBt (270mg, 2mmol in 10 ml CH<sub>2</sub>Cl<sub>2</sub>), DCC (413 mg, 2 mmol) was added at 0 °C, stirred 1h at that temperature, (*R*)-2 (356 mg, 1 mmol in 10 ml CH<sub>2</sub>Cl<sub>2</sub>) was added, stirred 24 hrs at room temperature, the solution was washed with aq. 5% K<sub>2</sub>CO<sub>3</sub> solution, extracted with dichloromethane, dried and evaporated solvent to give crude oil. This material was purified by flash column chromatography on silica gel, eluting with dichloromethane-methanol-

ammonia (100:1:1), to give (*R*)-**3d** (628 mg, 95%), <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.35 (9H, s), 1.70-1.87 (4H, m), 2.32-3.16 (6H, m), 3.35-4.46 (6H, m), 4.80-5.68 (6H, m), 7.07-7.45 (8H, m). The compound was used directly into the reaction below.

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#### Example 7

(*R*)-4-Aspartic acid-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]-piperazine dihydrochloride [(*R*)-**3e** 2HCl]

ADL-01-0041-2

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+The compound (*R*)-**3d** was dissolved into 1 ml of HOAc, and HCl (1 ml, 2N) was added, standing 20 min, then hydrogenated at 1 atm., 10% Pd on carbon at room temperature for 1 h to afford a white salt (*R*)-**3e** (430 mg, 91.5%): mp 168 °C (d). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 1.92-2.16 (4H, m), 2.75-5.28 (18H, m), 2.72 (3H, s), 7.31-7.52 (3H, m), 8.45-8.80 (3H, m); MS (FAB) 471 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>21</sub>H<sub>28</sub>Cl<sub>2</sub>N<sub>4</sub>O<sub>4</sub> · 2 HCl: C, 46.34; H, 5.18; N, 10.29. Found: C, 45.52; H, 6.02; N, 9.73.

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#### Example 8

20 (*R*)-4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]-piperazine hydrochloride [(*R*)-**3f** HCl]

ADL-01-0148-5

The compound was prepared as reported in the literature (*J. Med. Chem.* 1993, 36, 2075-2083) from (*R*)-**2**. the hydrochloride salt was prepared from 1M etherial HCl to afford (*R*)-**3f** HCl in 88% yield; mp 153-155°C; MS (FAB) 398 (M + H)<sup>+</sup>. Anal. Calcd for C<sub>19</sub>H<sub>25</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>2</sub> · HCl · H<sub>2</sub>O: C, 52.49; H, 6.03; N, 9.66. Found: C, 50.40; H, 6.23; N, 9.28.

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#### Example 9

30 (*R*)-4-(Diethoxyphosphonate)-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]-piperazine hydrochloride [(*R*)-**3g** HCl]

ADL-01-0149-3

35 To a solution of (*R*)-**2** (0.178 g, 0.5 mmol) in 10 mL of CH<sub>2</sub>Cl<sub>2</sub>, was added Et<sub>3</sub>N (0.101 g, 1.0 mmol) and diethylchlorophosphonate (0.174 g, 1.0 mmol) under a nitrogen atmosphere. The reaction mixture was stirred at room temperature for 13 h and then poured over aqueous 10% K<sub>2</sub>CO<sub>3</sub>. The organic layer was separated, dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>, and evaporated to dryness under reduced pressure to give the compound as a yellow oil. The oil was purified on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH, 95:5:2) and converted to hydrochloride salt by usual method to give (*R*)-**3g** HCl, 0.10 g (38%); mp 168-170°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.20 (6H, t, J = 7.0 Hz), 1.64 (4H, m), 2.30-2.70 (6H, m), 2.85-3.15 (1H, m), 3.45-3.80 (4H, m), 3.60 (2H, brs), 3.98 (4H, m), 4.35 (1H, m), 4.70 (1H, m), 7.00 (1H, m), 7.30 (2H, m); MS (FAB) 492, 494 (M + H)<sup>+</sup>. Anal. Calcd for C<sub>21</sub>H<sub>32</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>4</sub>P · HCl · 0.5H<sub>2</sub>O: C, 46.90; H, 6.37; N, 7.81. Found: C, 46.66; H, 5.90; N, 8.16.

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**Example 10****(R)-4-Trifluoroacetyl-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]-piperazine hydrochloride [(R)-3h HCl]****ADL-01-0150-1**

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To a solution of (R)-2 (0.356 g, 1.0 mmol) in 10 mL of CH<sub>2</sub>Cl<sub>2</sub> was added Et<sub>3</sub>N (0.202 g, 2.0 mmol) and trifluoroacetic anhydride (0.42 g, 2.0 mmol) in a nitrogen atmosphere. The reaction mixture was stirred at room temperature for 12h and TLC showed starting material was still present, added another equivalent of trifluoroacetic anhydride and stirring was continued for additional 12 h. The reaction was worked up as above and the hydrochloride salt was prepared as usual to give (R)-3h HCl, 0.25 g (50%); mp 145-147°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.60 (4H, m), 2.20-2.75 (6H, m), 3.10 (1H, m), 3.45-3.80 (4H, m), 4.00 (1H, J = 14.0 Hz, d), 4.25 (1H, m), 4.45 (1H, J = 14.0 Hz, d), 4.70 (1H, m), 7.00 (1H, m), 7.28 (2H, m); MS (FAB) 452, 454 (M + H)<sup>+</sup>. Anal. Calcd for C<sub>19</sub>H<sub>22</sub>Cl<sub>2</sub>F<sub>3</sub>N<sub>3</sub>O<sub>2</sub>·HCl·0.5H<sub>2</sub>O: C, 45.85; H, 4.86; N, 8.44. Found: C, 46.26; H, 4.82; N, 8.33.

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**Example 11****(R)-4-[(3,4-Dichlorophenyl)acetyl]-3-[(1-pyrrolidinyl)methyl]-1-piperazinecarboxamide hydrochloride [(R)-3i HCl]****ADL-01-0151-9**

To a solution of (R)-2 (0.356 g, 1.0 mmol) in acetic acid (0.186 g, 3.0 mmol) and water was added KOCN (0.244 g, 3.0 mmol) and the reaction mixture was stirred at room temperature for 72 h. An aqueous 10% K<sub>2</sub>CO<sub>3</sub> was added to the reaction mixture to bring the pH to near 12.0 and the product was extracted with CH<sub>2</sub>Cl<sub>2</sub>, washed with saturated salt solution, dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. The removal of solvent at reduced pressure gave the crude product which was purified on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH, 95:5:1) to give the desired product as a white solid. The hydrochloride salt was prepared from 1M ethelial HCl to give (R)-3i HCl as a white solid, 0.15 g (31%); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.65 (4H, m), 2.10-3.20 (6H, m), 3.40-3.70 (4H, m), 3.95 (2H, m), 4.20 (2H, J = 14.0 Hz, d,m), 4.70 (1H, m), 5.35 (2H, bs), 7.00 (1H, m), 7.25 (2H, m); MS (FAB) 399, 401 (M + H)<sup>+</sup>. Anal. Calcd for C<sub>18</sub>H<sub>24</sub>Cl<sub>2</sub>N<sub>4</sub>O<sub>2</sub>·HCl·H<sub>2</sub>O·0.125 CH<sub>2</sub>Cl<sub>2</sub>: C, 46.88; H, 5.91; N, 12.06. Found: C, 46.66; H, 5.50; N, 11.97.

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**Example 12****(R)-4-[(3,4-Dichlorophenyl)acetyl]-3-[(1-pyrrolidinyl)methyl]-1-piperazinecarboxaldehyde hydrochloride [(R)-3j HCl]****ADL-01-0156-8**

To a solution of (R)-2 (0.356 g, 1.0 mmol) in 10 mL of CH<sub>2</sub>Cl<sub>2</sub> was added 1.0 mL of methylformate (excess) at 0°C under a nitrogen atmosphere. The reaction mixture was stirred for 24 h and solvent was removed at reduced pressure to give the crude product. The compound was purified on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH, 95:5:1) and converted to the hydrochloride salt, (R)-3j HCl, 0.10 g (23%); mp 126°C (d); <sup>1</sup>H

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NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.62 (4H, m), 2.10-3.20 (6H, m), 3.35-3.85 (5H, m), 4.25 (3H, m), 4.60 (1H, m), 7.00 (1H, m), 7.26 (2H, m), 7.90 (1H, s); MS (FAB) 384, 386 (M + H)<sup>+</sup>.

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### Example 13

(R)-4-[(3,4-Dichlorophenyl)acetyl]-3-[(1-pyrrolidinyl)methyl]-1-piperazine-sulfonamide hydrochloride [(R)-3k HCl]

ADL-01-0164-2

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To a solution of (R)-2 (0.356 g, 1.0 mmol) in 5 mL of p-dixane was added sulfamide<sup>4</sup> (NH<sub>2</sub>SO<sub>2</sub>NH<sub>2</sub>, 0.96 g, 10 mmol) under a nitrogen atmosphere and the reaction mixture was heated to reflux for 2 h. The reaction mixture was evaporated to dryness under reduced pressure and the residue was redissolved in CH<sub>2</sub>Cl<sub>2</sub> and washed with aqueous 10% K<sub>2</sub>CO<sub>3</sub>, saturated salt solution, and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. The removal of solvent resulted the free base of the product which was purified on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH, 98:2:1). The hydrochloride salt was prepared from 1M etherial HCl to give (R)-3k HCl, 0.10 g (21%); mp 183-185°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.68 (4H, m), 2.30-3.00 (6H, m), 3.15-4.00 (5H, m), 4.15-4.65 (3H, m), 4.85 (1H, m), 7.00 (1H, m), 7.31 (4H, m); MS (FAB) 435 (M + H)<sup>+</sup>. Anal. Calcd for C<sub>17</sub>H<sub>24</sub>Cl<sub>2</sub>N<sub>4</sub>O<sub>3</sub>S.HCl: C, 43.28; H, 5.34; N, 11.87. Found: C, 42.90; H, 5.35; N, 11.43.

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### Ref.

(4) Alker, D. et. al. *J. Med. Chem.* 1990, 33, 585.

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### Example 14

(R)-4-(4-Methoxyphenylsulfonyl)-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]-piperazine hydrochloride [(R)-3l HCl]

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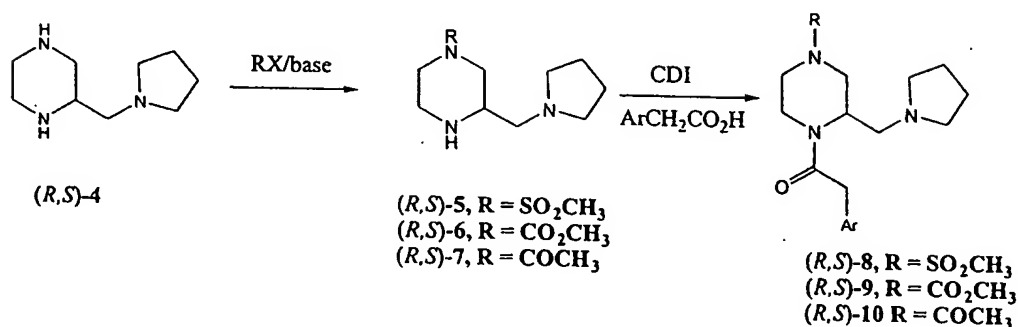
ADL-01-0165-9

To a solution of (R)-2 (0.356 g, 1.0 mmol) in 5 mL of CH<sub>2</sub>Cl<sub>2</sub> was added p-toluenesulfonyl chloride (0.38 g, 2 mmol) followed by 0.5 mL of pyridine under a nitrogen atmosphere. The reaction mixture was stirred at room temperature for 16 h and then poured onto aqueous 10% K<sub>2</sub>CO<sub>3</sub>. The organic layer was separated and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. The removal of solvent gave the product which was purified on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH, 98:2:1). The hydrochloride salt was prepared to give (R)-3l HCl, 0.15 g (27%); mp 240°C (d); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.65 (4H, m), 1.95-3.00 (6H, m), 2.38 (3H, s), 3.15-3.85 (5H, m), 4.45 (1H, m), 4.75 (1H, m), 6.95 (1H, m), 7.25 (4H, m), 7.50 (2H, J = 8.0 Hz, d); MS (FAB) 510 (M + H)<sup>+</sup>. Anal. Calcd for C<sub>24</sub>H<sub>29</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>3</sub>S.HCl.0.25H<sub>2</sub>O: C, 52.32; H, 5.35; N, 7.63. Found: C, 52.23; H, 5.50; N, 7.51.

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**Racemic Compounds**

Racemic compounds were prepared as illustrated by the following steps.

**(R,S)-2-[(1-Pyrrolidinyl)methyl]piperazine hydrochloride [(R,S)-4 HCl]**

The compound was prepared following the literature procedure<sup>1</sup> and isolated as hydrochloride salt.

**(R,S)-4 (R = SO<sub>2</sub>CH<sub>3</sub>, CO<sub>2</sub>CH<sub>3</sub>, COCH<sub>3</sub>)-2-[(1-Pyrrolidinyl)methyl]piperazine hydrochloride [(R,S)-5, 6, 7]**

These compounds were also prepared according to the procedures described in the literature<sup>1</sup> and each of the products were purified as free base before utilizing below.

**Example 15****(R,S)-4-Methanesulfonyl-1-[(3,4-dichlorophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]piperazine hydrochloride [(R,S)-8a HCl] (General Procedure)**

ADL-01-0135-2

- 1,1'-Carbonyldiimidazole (0.324 g, 2.0 mmol) was added to a stirred solution of 3,4-dichlorophenylacetic acid (0.41 g, 2.0 mmol) in 10 mL of CH<sub>2</sub>Cl<sub>2</sub> at room temperature under a nitrogen atmosphere, and the resulting solution was continued stirring for additional 1 h. The resulting solution was then added to a stirred solution of (R,S)-5 (0.247 g, 1.0 mmol) in 10 mL of CH<sub>2</sub>Cl<sub>2</sub> at 0°C and the reaction mixture was stirred for further 20 h. The reaction mixture was diluted with CH<sub>2</sub>Cl<sub>2</sub> and washed with aqueous 2M Na<sub>2</sub>CO<sub>3</sub>. The organic layer was dried and evaporated to dryness and the product was purified on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH, 98:2:1). The hydrochloride salt was prepared by redissolving the compound in CH<sub>2</sub>Cl<sub>2</sub> and treating the solution with 1M ethereal HCl to give (R,S)-8a HCl as a white solid, 0.20 g (32%); NMR (see R-3a); MS (FAB) 434 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>18</sub>H<sub>25</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>3</sub>S·HCl·0.5H<sub>2</sub>O: C, 45.13; H, 5.51; N, 8.77. Found: C, 45.46; H, 5.36; N, 8.71.

The following compounds were similarly prepared from (R,S)-5, 6, and 7:

**Example 16****(R,S)-4-Methanesulfonyl-1-[(4-methylsulfonylphenyl)acetyl]-2-[(1-pyrrolidinyl)-methyl]piperazine hydrochloride [(R,S)-8b HCl]**5 **ADL-01-0117-0**

The compound was prepared from 4-methylsulfonylphenylacetic acid and the hydrochloride salt was recrystallized from CH<sub>3</sub>OH to give (R,S)-8b HCl in 60% yield; mp 185-188°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.65 (4H, m), 2.30-2.70 (6H, m), 2.80 (3H, s), 2.85-3.10 (3H, m), 3.00 (2H, m), 3.25 (1H, m), 3.50-3.95 (4H, m), 4.50 (1H, m), 4.80 (1H, m), 7.40 (2H, J = 7.5 Hz, d), 7.80 (2H, J = 7.5 Hz, d); MS (FAB) 444 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>19</sub>H<sub>29</sub>N<sub>3</sub>O<sub>3</sub>S<sub>2</sub>·HCl: C, 47.54; H, 6.30; N, 8.75. Found: C, 46.03; H, 6.24; N, 8.80.

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**Example 17****(R,S)-4-Methanesulfonyl-1-[(2-nitrophenyl)acetyl]-2-[(1-pyrrolidinyl)-methyl]piperazine hydrochloride [(R,S)-8c HCl]****ADL-01-0119-6**

20 The compound was prepared from 2-nitrophenylacetic acid in 65% yield as hydrochloride salt; mp 253-255°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.70 (4H, m), 2.40-3.10 (6H, m), 2.75 (3H, s), 3.45 (1H, m), 3.70-4.00 (4H, m), 4.05-4.30 (2H, m), 4.50 (1H, m), 4.72 (1H, m), 7.45 (3H, m), 8.05 (1H, J = 8.0 Hz, d); MS (FAB) 411 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>18</sub>H<sub>26</sub>N<sub>4</sub>O<sub>5</sub>S·HCl: C, 48.37; H, 6.09; N, 12.54. Found: C, 48.36; H, 5.66; N, 12.29.

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**Example 18****(R,S)-4-Methanesulfonyl-1-[(4-trifluoromethylphenyl)acetyl]-2-[(1-pyrrolidinyl)-methyl]piperazine hydrochloride [(R,S)-8d HCl]****ADL-01-0120-4**

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The compound was prepared as a hydrochloride salt from 4-trifluoromethylphenylacetic acid in 82% yield; 182-185°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.65 (4H, m), 2.35-3.05 (6H, m), 2.71 (3H, s), 3.25 (1H, m), 3.50-3.95 (5H, m), 4.55 (1H, m), 4.85 (1H, m), 7.30 (2H, m), 7.50 (2H, J = 7.8 Hz, d); MS (FAB) 434 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>19</sub>H<sub>26</sub>F<sub>3</sub>N<sub>3</sub>O<sub>3</sub>S·HCl·0.5H<sub>2</sub>O: C, 47.65; H, 5.89; N, 8.77. Found: C, 48.36; H, 5.80; N, 8.51.

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**Example 19****(R,S)-4-Methanesulfonyl-1-[(3-indolylacetyl)-2-[(1-pyrrolidinyl)-methyl]piperazine hydrochloride [(R,S)-8e HCl]**

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**ADL-01-0134-5**

The compound was prepared from 3-indoleacetic acid and isolated as free base in 40% yield and converted to hydrochloride salt; mp 219-221°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.65 (4H, m), 2.10-3.00 (6H, m), 2.55 (3H, s), 3.10-3.45 (2H, m), 3.45-3.90 (4H, m), 4.05 (1H, m), 4.55 (1H, m), 4.90 (1H, m), 7.05 (3H, m), 7.25 (1H, m), 7.50 (1H, m), 8.95 (1H, bs);

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MS (FAB) 405 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>20</sub>H<sub>28</sub>N<sub>4</sub>O<sub>3</sub>S.HCl.0.5H<sub>2</sub>O: C, 58.09; H, 7.07; N, 13.55. Found: C, 58.37; H, 6.68; N, 13.30.

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**Example 20**

**(R,S)-Methyl 4-[(4-methylsulfonylphenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]-1-piperazinecarboxylate hydrochloride [(R,S)-9a HCl]**

**ADL-01-0092-5**

- 10 The compound was prepared from 4-methylsulfonylphenylacetic acid and the hydrochloride was prepared from 1M etherial HCl to give (R,S)-9a HCl in 46 % yield; mp 225°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.60 (4H, m), 2.15-2.95 (6H, m), 2.98 (3H, s), 3.15 (2H, m), 3.35 (3H, m), 3.60 (3H, s), 3.95 (2H, m), 4.30 (1H, m), 4.72 (1H, m), 7.45 (2H, m), 7.75 (2H, J = 7.5 Hz, d); MS (FAB) 424 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>20</sub>H<sub>29</sub>N<sub>3</sub>O<sub>3</sub>S.HCl.0.25H<sub>2</sub>O: C, 51.72; H, 6.62; N, 9.05. Found: C, 51.93; H, 6.47; N, 8.44.

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**Example 21**

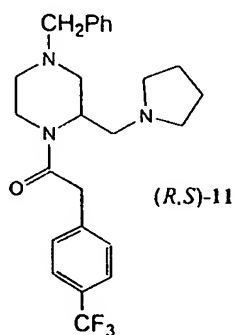
**(R,S)-Methyl 4-[(4-trifluoromethylphenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]-1-piperazinecarboxylate hydrochloride [(R,S)-9b HCl]**

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**ADL-01-0094-1**

- The compound was prepared as a hydrochloride salt from 4-trifluoromethylphenylacetic acid to give (R,S)-9b HCl in 48%; mp 210°C; <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.50 (4H, m), 1.95-2.30 (6H, m), 2.35-3.50 (4H, m), 3.65 (3H, s), 3.70-4.50 (5H, m), 7.45 (4H, m); MS (FAB) 414 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>20</sub>H<sub>26</sub>F<sub>3</sub>N<sub>3</sub>O<sub>3</sub>.HCl.0.25H<sub>2</sub>O: C, 52.86; H, 6.10; N, 9.25. Found: C, 53.03; H, 5.94; N, 8.94.

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Another minor product (R,S)-11 (ADL-01-0093-3) was isolated as a hydrochloride salt from this reaction in 10% yield; mp 190°C; MS (FAB) 446 (M + H)<sup>+</sup>.



**Example 22**

**(R,S)-Methyl 4-[(3-indolyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]-1-piperazine-carboxylate hydrochloride [(R,S)-9c HCl]**

5 **ADL-01-0095-8**

The compound was prepared from 3-indoleacetic acid and the hydrochloride salt was prepared to give (R,S)-9c HCl in 75% yield; mp 143°C; <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.55 (4H, m), 1.90-2.52 (6H, m), 2.70-3.75 (9H, m), 3.35 (3H, s), 6.60 (2H, m), 6.85 (2H, m), 7.20 (1H, s), 7.65 (1H, brs); MS (FAB) 385 (M + H)<sup>+</sup>.

**Example 23**

**(R,S)-Methyl 4-[(2-nitrophenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]-1-piperazine-carboxylate hydrochloride [(R,S)-9d HCl]**

15 **ADL-01-0096-6**

The compound was prepared from 2-nitrophenylacetic acid and hydrochloride was prepared from 1M etherial HCl to give (R,S)-9d HCl in 42% yield; mp 228°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.60 (4H, brs), 1.80-2.30 (4H, m), 2.70 (2H, m), 3.05 (2H, m), 3.60 (3H, s), 3.55-4.10 (4H, m), 4.35 (2H, J = 14.0 Hz, dd), 5.10 (1H, m), 7.50 (3H, m), 8.05 (1H, J = 7.5 Hz, d); MS (FAB) 391 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>19</sub>H<sub>26</sub>N<sub>4</sub>O<sub>5</sub>.HCl: C, 53.46; H, 6.37; N, 13.12. Found: C, 54.29; H, 6.38; N, 12.58.

**Example 24**

**(R,S)-Methyl 4-[(2-methoxyphenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]-1-piperazine-carboxylate hydrochloride [(R,S)-9e HCl]**

25 **ADL-01-0097-4**

30 The compound was prepared as above from 2-methoxyphenylacetic acid to give (R,S)-9e HCl in 12% yield; mp 120°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.65 (4H, m), 2.25 - 2.95 (6H, m), 3.10 (1H, m), 3.30-4.10 (5H, m), 3.60 (3H, s), 3.70 (3H, s), 4.40 (1H, m), 4.70 (1H, m), 6.84 (2H, m), 7.15 (3H, m); MS (FAB) 376 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>20</sub>H<sub>29</sub>N<sub>3</sub>O<sub>5</sub>.HCl.H<sub>2</sub>O: C, 55.87; H, 7.50; N, 9.77. Found: C, 55.78; H, 6.97; N, 9.42.

**Example 25**

**(R,S)-Methyl 4-[(2-aminophenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]-1-piperazine-carboxylate dihydrochloride [(R,S)-9f 2HCl]**

40 **ADL-01-0098-2**

The compound was prepared by the hydrogenation of (R,S)-9e HCl on 10% Pd/C following the procedure described in the literature<sup>1</sup>. The compound, (R,S)-9f 2HCl, was isolated as dihydrochloride in 84% yield; mp 195°C (d); <sup>1</sup>H NMR (200 MHz, DMSO-d<sub>6</sub>) δ 2.00 (4H, m), 3.05-4.45 (16H, m), 3.75 (3H, s), 5.00 (1H, m), 7.45 (4H, brs); MS (FAB) 361 (M + H)<sup>+</sup>;

Anal. Calcd for  $C_{19}H_{28}N_4O_3 \cdot 2HCl \cdot H_2O$ : C, 50.56; H, 7.15; N, 12.41. Found: C, 50.36; H, 7.26; N, 12.05.

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**Example 26**

(R,S)-4-Acetyl-1-[(4-methylsulfonylphenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]-piperazine hydrochloride [(R,S)-10a HCl]

**ADL-01-0144-4**

- 10 The compound was prepared as above from 4-methylsulfonylphenylacetic acid and the hydrochloride salt was prepared in usual fashion to give (R,S)-10a HCl in 45% yield; mp 145-147°C;  $^1H$  NMR (200 MHz, DMSO- $d_6$ )  $\delta$  1.90 (4H, m), 2.17 (3H, s), 2.65-3.80 (6H, m), 3.32 (3H, s), 3.85-4.45 (8H, m), 5.05 (1H, m), 7.65 (2H, J = 8.0 Hz, d), 7.95 (2H, J = 8.0 Hz, d); MS (FAB) 408 (M + H) $^+$ .

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**Example 27**

(R,S)-4-Acetyl-1-(4-trifluoromethylphenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]piperazinecarboxylate hydrochloride [(R,S)-10b HCl]

20 **ADL-01-0145-1**

- The compound was prepared from 4-trifluoromethylphenylacetic acid and isolated as hydrochloride salt, (R,S)-10b HCl, in 30% yield; mp 110°C;  $^1H$  NMR (200 MHz, DMSO- $d_6$ )  $\delta$  2.00 (4H, m), 2.15 (3H, s), 2.70-3.25 (6H, m), 3.50-4.45 (8H, m), 5.05 (1H, m), 7.70 (4H, m); MS (FAB) 398 (M + H) $^+$ .

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**Example 28**

(R,S)-4-Acetyl-1-[(2-trifluoromethylphenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]piperazinecarboxylate hydrochloride [(R,S)-10c HCl]

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**ADL-01-0157-6**

- The compound was prepared from 2-trifluoromethylphenylacetic acid and the hydrochloride salt was made from 1M ethereal HCl to give (R,S)-10c HCl in 57%; 220°C (d);  $^1H$  NMR (free base, 200 MHz,  $CDCl_3$ )  $\delta$  1.65 (4H, m), 2.05 (3H, s), 2.25-3.25 (6H, m), 3.40-4.10 (6H, m), 4.50 (2H, m), 4.70 (1H, m), 7.30 (2H, m), 7.60 (2H, m); MS (FAB) 398 (M + H) $^+$ .

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**Example 29**

(R,S)-4-Acetyl-1-[(3-nitrophenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]piperazinecarboxylate hydrochloride [(R,S)-10d HCl]

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**ADL-01-0158-4**

- The compound was prepared from 3-nitrophenylacetic acid and the hydrochloride salt, (R,S)-10d HCl was isolated as a white solid in 69% yield; mp 143-145°C;  $^1H$  NMR (free base, 200

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MHz, CDCl<sub>3</sub>) δ 1.63 (4H, brs), 2.05 (3H, s), 2.20-2.80 (6H, m), 2.90-3.25 (2H, m), 3.50-3.90 (3H, m), 4.00 (1H, J = 14.0 Hz, d), 4.45 (2H, m), 4.65 (1H, m), 7.45 (2H, m), 8.00 (2H, m); MS (FAB) 375 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>19</sub>H<sub>26</sub>N<sub>4</sub>O<sub>4</sub>·HCl·H<sub>2</sub>O: C, 53.21; H, 6.81; N, 13.06. Found: C, 53.51; H, 6.13; N, 12.91.

#### Example 30

(R,S)-4-Acetyl-1-[(2-nitrophenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]piperazine-carboxylate hydrochloride [(R,S)-10e HCl]

ADL-01-0163-4

The compound was prepared as above from 2-nitrophenylacetic acid to give (R,S)-10e HCl as white solid in 50% yield; mp 180°C (d); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.63 (4H, m), 2.04 (3H, s), 2.20-2.85 (6H, m), 2.98-3.35 (3H, m), 3.60-4.25 (4H, m), 4.60 (2H, m), 7.35 (3H, m), 8.00 (1H, J = 7.0 Hz, d); MS (FAB) 375 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>19</sub>H<sub>26</sub>N<sub>4</sub>O<sub>4</sub>·HCl·0.5H<sub>2</sub>O: C, 55.54; H, 6.62; N, 13.64. Found: C, 54.38; H, 6.35; N, 13.58.

#### Example 31

(R,S)-4-Acetyl-1-[(4-nitrophenyl)acetyl]-3-[(1-pyrrolidinyl)-methyl]piperazine-carboxylate hydrochloride [(R,S)-10f HCl]

ADL-01-0159-2

The compound was prepared from 2-nitrophenylacetic acid as before to give (R,S)-10f HCl in 52% yield; 146-148°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.68 (4H, m), 2.07 (3H, s), 2.20-2.75 (6H, m), 3.40-3.90 (3H, m), 4.05 (1H, J = 13.5 Hz, d), 4.50 (2H, m), 7.35 (2H, J = 8.0 Hz, d), 8.10 (2H, J = 8.0 Hz, d); MS (FAB) 375 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>19</sub>H<sub>26</sub>N<sub>4</sub>O<sub>4</sub>·HCl·0.5H<sub>2</sub>O·0.125CH<sub>2</sub>Cl<sub>2</sub>: C, 53.36; 6.61; 13.01. Found: C, 53.16; H, 6.27; N, 13.36.

#### Example 32

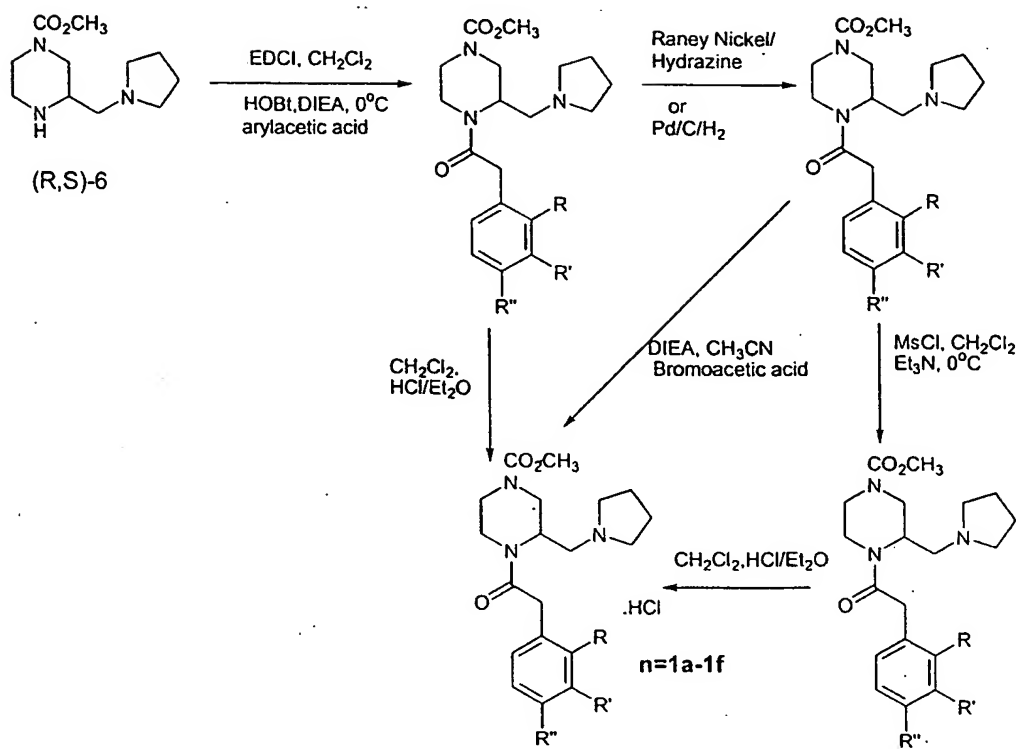
(R,S)-4-(Phenylmethyl)-1-[(4,5-dichloro-2-nitrophenyl)acetyl]-2-[(1-pyrrolidinyl)methyl]piperazine dihydrochloride [(R,S)-12 2HCl]

ADL-01-0166-7

The compound was prepared from 4-phenylmethyl-2[(1-pyrrolidinyl)methyl]piperazine (Ref. 1) and 4,5-dichloro-2-nitrophenylacetic acid following the method described above to give (R,S)-12 2HCl in 63% yield; mp 235°C (d); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.66 (4H, m), 2.05-3.00 (8H, m), 3.45 (4H, m), 4.00 (5H, m), 4.60 (1H, m), 7.35 (6H, m), 8.15 (1H, s); MS (FAB) 493 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>24</sub>H<sub>29</sub>Cl<sub>2</sub>N<sub>4</sub>O<sub>3</sub>·2HCl: C, 50.99; 5.53; 9.91. Found: C, 50.55; H, 5.16; N, 9.44.

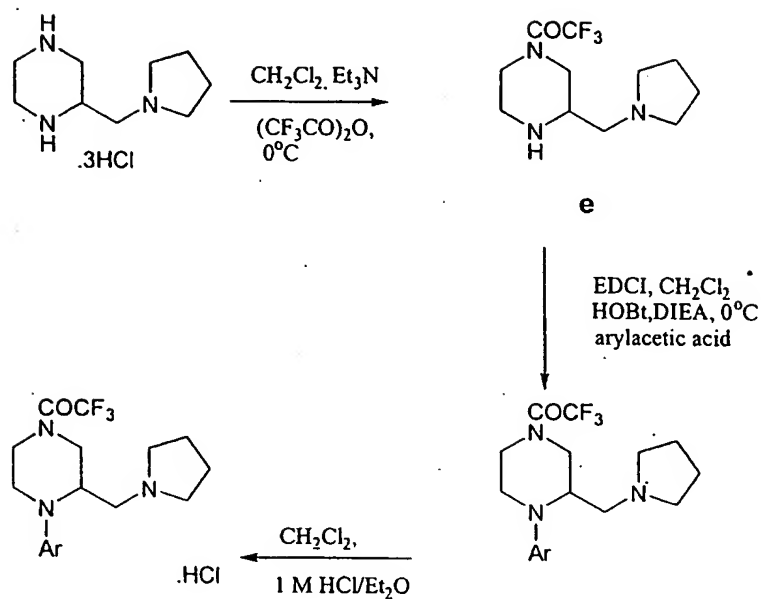
The preparation of compounds of formula IA (compounds 1a through 1qq) follow according to Schemes A, B, C, D, E and F.

## Scheme A



Compound 1a: R = -NHCH<sub>2</sub>CO<sub>2</sub>H, R' = H, R'' = CF<sub>3</sub>  
 Compound 1b: R = -NMs<sub>2</sub>, R' = H, R'' = CF<sub>3</sub>  
 Compound 1c: R = -NHMs, R' = H, R'' = H  
 Compound 1d: R = -NMs<sub>2</sub>, R' = H, R'' = H  
 Compound 1e: R = -SO<sub>2</sub>NHCH<sub>3</sub>, R' = H, R'' = H  
 Compound 1f: R = -H, R' = H, R'' = -SO<sub>2</sub>NHCH<sub>3</sub>

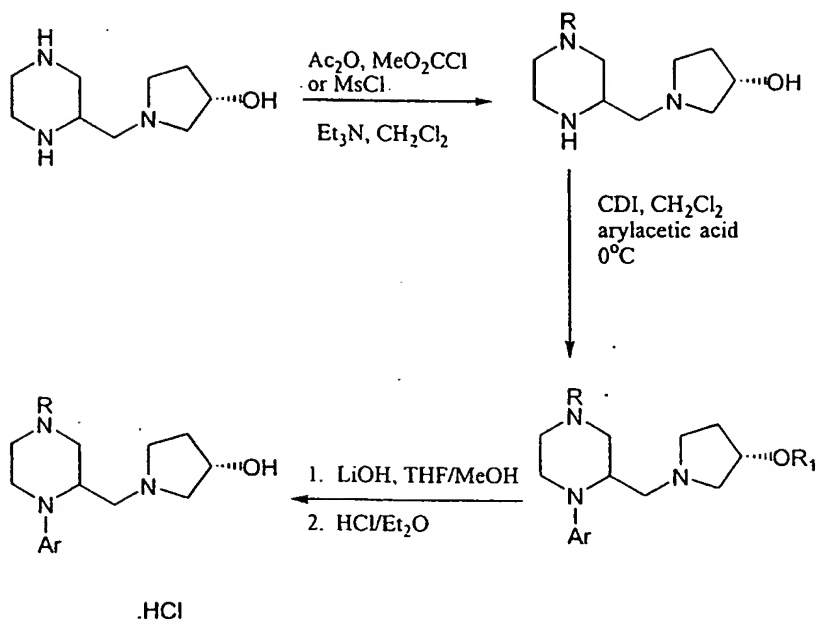
## Scheme B



Compound 1g : Ar = -trans-3-furanacrylyl

Compound 1h : Ar = -4-trifluoromethylphenyl acetyl

## Scheme C



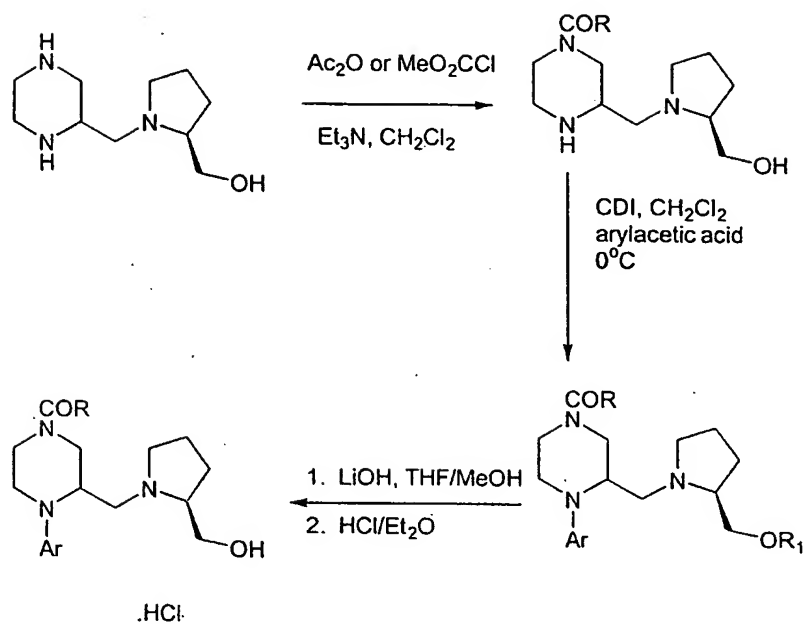
1ll: R= -Ms, Ar= -3,4-dichlorophenylacetyl

1nn: R= -Ms, Ar= -4-trifluorophenylacetyl

1j: R= -CO<sub>2</sub>CH<sub>3</sub>,  
R<sub>1</sub>=Ar= -4-trifluorophenylacetyl

1u: R=COCH<sub>3</sub>,  
R<sub>1</sub>=Ar=4-methylsulphonyl  
phenylacetyl

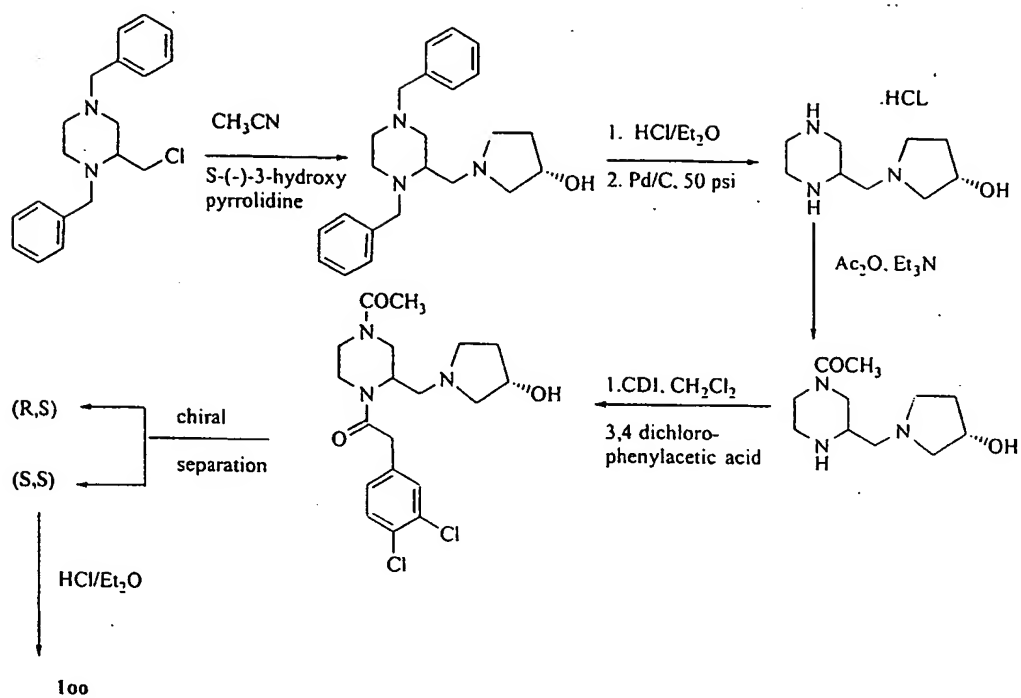
## Scheme D



**1l:** R=CO<sub>2</sub>CH<sub>3</sub>,  
 Ar=3,4-dichlorophenylacetyl  
**1bb:** R=COCH<sub>3</sub>,  
 Ar=4-methylsulphonylphenylacetyl

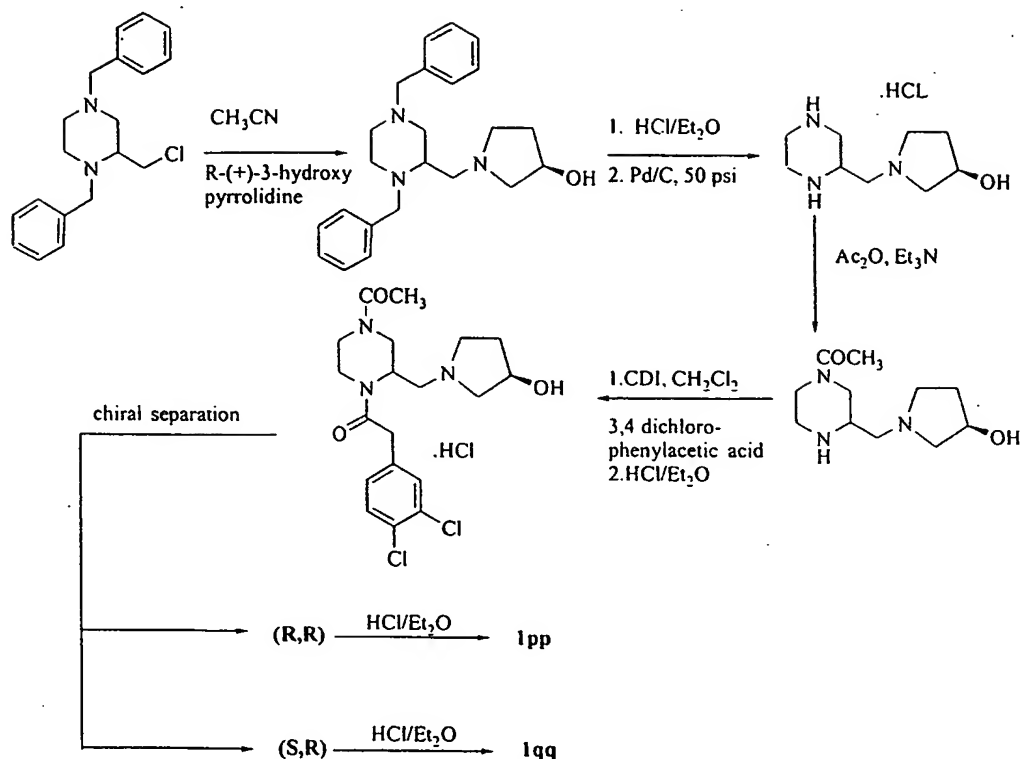
**1k:** R=CO<sub>2</sub>CH<sub>3</sub>,  
 R<sub>1</sub>=Ar=3,4-dichlorophenylacetyl  
**1aa:** R=COCH<sub>3</sub>,  
 R<sub>1</sub>=Ar=4-methylsulphonylphenylacetyl

## Scheme E





## Scheme F



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## EXAMPLE 1a

**Methyl-4-[(2-glycyl-4-(trifluoromethylphenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl)-methyl]-1-piperazinecarboxylate**

**Methyl-4-[(2-nitro-4-trifluoromethylphenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl)-methyl]-1-piperazinecarboxylate<sup>1</sup> (Procedure A) (a):** To a solution of 2-nitro-4-trifluorophenylacetic acid (2.8 g, 11.2 mmol) in 30 mL of dry CH<sub>2</sub>Cl<sub>2</sub> under a nitrogen atmosphere was added HOBt (1.3 g, 9.6 mmol). The reaction mixture is stirred at 0°C and added solid EDCI (2.25 g, 11.75 mmol). Then, stirred for 30 minutes at 0°C. A solution of methyl-3-(R,S)-[(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate<sup>1</sup> (2.0 g, 8.78 mmol) in 5 mL of dry CH<sub>2</sub>Cl<sub>2</sub> was added followed by DIEA (1.68 mL, 9.64 mmol). The reaction mixture was stirred for 24 h while warming to room temperature. The reaction mixture was then poured into water (50 mL) and stirred for 30 minutes. After dilution with CH<sub>2</sub>Cl<sub>2</sub>, the organic layer was separated, washed with saturated NaHCO<sub>3</sub> salt solution, and water. Then, dried over MgSO<sub>4</sub>. The compound was purified by flash column chromatography on silica gel, eluting with CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:(98:2) to give the desired product as a free base (3.15 g, 78% yield). Then, proceed on to the next step. <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.76 (4H,

m), 2.65 (4H, m), 3.02 (2H, m), 3.74 (s, 3H), 4.21 (4H, m), 7.56 (dd, J=2.4, 8.0 Hz, 1H), 7.85 (d, J=8.0 Hz, 1H), 8.4 (d, J=2.4 Hz, 1H); MS(FAB) m/z 459.

**Methyl-4-[(2-amino-4-trifluoromethylphenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl)-methyl]-1-piperazinecarboxylate hydrochloride (b):** Compound a (1.18 gm, 2.57 mmol) was dissolved in ethanol (50 mL) and heated to 55°C. Hydrazine hydrate (0.9 mL, 28.12 mmol) and 1 scoop of Raney Nickel was added to the reaction flask. Stir vigorously. Continue to add the Raney Nickel until all of the hydrazine is consumed (when the bubbling has stopped). Cool to 30°C and filter through celite and wash with hot methanol. (Do not allow the Raney nickel to become dry!). Evaporate the solvent and generate an HCl salt (1.0 gm; 90.6%); m.p. 160-165°C. <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.76 (4H, m), 2.5-3.1 (7H, m), 3.74 (3H, s), 4.15 (2H, m), 4.55 (2H, m), 6.90 (1H, J=2.4 Hz, d), 6.95 (1H, J=2.4, 8.0 Hz, dd), 7.15 (1H, J=8.0 Hz, d). MS (FAB) m/z 429. Anal. Calc. For C<sub>20</sub>H<sub>27</sub>N<sub>4</sub>F<sub>3</sub>O<sub>3</sub>·HCl·H<sub>2</sub>O: C, 49.69; H, 6.21; N, 11.60. Found: C, 49.57; H, 6.04; N, 11.32.

To a solution of bromoacetic acid (0.356 g, 2.56 mmol) and DIEA (1.0 mL, 5.74 mmol) in CH<sub>3</sub>CN (15 mL) was added compound b and heated to 55°C for 16 hr. Then, heated to 75°C for 4 hr. The reaction was complete. Evaporate the solvent and re-dissolve in ethanol (25.0 mL). Add 0.1 M Na<sub>2</sub>CO<sub>3</sub> (20 mL) and filter and wash with boiling ethanol (15 mL). Evaporate the filtrate and dissolve in isopropanol (10 mL). Add diethyl ether (5.0 mL) until precipitate forms. Filtered. A white solid is obtained (m.p. 165-170°C; 0.3 g, 24.8 % yield). <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 2.19 (4H, m), 2.95 (4H, m), 3.2-3.7 (4H, m), 3.74 (3H, s), 3.8-4.2 (4H, m), 4.7 (1H, m), 5.2 (1H, m), 6.86 (1H, J=2.4 Hz, d), 7.0 (2H, J=8.0 Hz, d). MS (FAB) m/z 487. Anal. Calc. For C<sub>22</sub>H<sub>29</sub>N<sub>4</sub>F<sub>3</sub>O<sub>5</sub>·0.5 C<sub>2</sub>H<sub>6</sub>O·0.5 H<sub>2</sub>O: C, 53.28; H, 6.37; N, 10.81. Found: C, 53.50; H, 6.25; N, 10.51.

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#### EXAMPLE 1b

##### Methyl-4-[(2-[N,N-bis-methylsulfonamido]-4-trifluoromethylphenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl)-methyl]-1-piperazinecarboxylate dihydrochloride

To a solution of compound b (0.4 g, 0.933 mmol) and triethylamine (0.26 mL, 1.86 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (10.0 mL) at 0°C was added methanesulfonyl chloride (0.144 mL, 1.86 mmol). The reaction was stirred for 16 hr. The reaction was diluted with CH<sub>2</sub>Cl<sub>2</sub> (40.0 mL), washed with saturated NaHCO<sub>3</sub> solution and water. Then, dried over MgSO<sub>4</sub>. Then, isolated on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (98:2:2) to give the desired product as a free base (0.4 g, 73 %). Evaporate the solvent and generate an HCl salt (0.14 gm; m.p. 155-160°C). <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.76 (4H, m), 2.75-3.31 (11H, m), 3.47 (3H, s), 3.50 (3H, s), 3.72 (3H, s), 3.8-4.3 (5H, m), 4.55 (1H, m), 4.95 (1H, m), 7.5-7.9 (3H, Ar). MS (FAB) m/z 585. Anal. Calc. For C<sub>22</sub>H<sub>31</sub>N<sub>4</sub>F<sub>3</sub>O<sub>7</sub>S<sub>2</sub>·2HCl: C, 42.54; H, 5.19; N, 9.02. Found: C, 42.58; H, 5.23; N, 8.91.

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#### EXAMPLE 1c

##### Methyl-4-[(2-[N-methylsulfonamido]phenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate hydrochloride

**Methyl-4-[(2-nitro-phenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate (c):** The compound was prepared from 2-nitro-phenylacetic acid following Procedure A and isolated on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (99:1:2) to give the desired product as a free base (3.15 g, 78 %).

Then, proceed on to the next step.. <sup>1</sup>H NMR (free base 300MHz, CDCl<sub>3</sub>) δ 1.75 (4H, m), 2.53 (4H, m), 3.02 (2H, m), 3.74 (s, 3H), 4.21 (4H, m), 7.4 (1H, ArH, m) 7.56 (1H, J=1.2Hz, d), 7.61 (1H, J= 1.2, 7.4Hz, dd), 8.11 (1H, J=8.0Hz, d).

5 **Methyl-4-[(2-amino-phenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate (d):** Then, compound c was dissolved in ethanol(200 mL) and Pd/C (Degussa; 10%; 3.0 g) were added into a Parr bottle (500 mL). Then, the bottle was attached to a Parr Shaker Hydrogenator at 50 psi for 6 hr. The reaction was complete. This was filtered through celite. Evaporate the solvent and proceed on to the final step.

10 Then, to a solution of the above compound d (0.15 g, 0.33 mmol) and triethylamine(0.10 mL, 0.66 mmol) in CH<sub>2</sub>Cl<sub>2</sub>(10.0 mL) at 0°C was added methanesulfonyl chloride(0.026 mL, 0.33 mmol). The reaction was stirred for 16 hr. The reaction was diluted with CH<sub>2</sub>Cl<sub>2</sub>(20.0 mL), washed with saturated NaHCO<sub>3</sub> solution and water. Then, dried over Mg<sub>2</sub>SO<sub>4</sub>. Then, isolated on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (98:2:2) to give the desired product as a free base (0.1 g, 68 %). Evaporate the solvent and generate an HCl salt(0.06gm; m.p. 130-135°C). <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.75 (4H, m), 2.2 (1H, m), 2.5-3.1 (6H, m), 3.01 (3H, s), 3.50 (2H, m), 3.73 (3H, s), 3.8-4.5(5H, m), 5.02 (1H, m), 6.88-7.55(3H, Ar). MS (FAB) m/z 439. Anal. Calc. For C<sub>20</sub>H<sub>30</sub>N<sub>4</sub>O<sub>3</sub>S<sub>2</sub>.HCl: C, 50.57; H, 6.58; N, 11.79. Found: C, 50.55; H, 6.64; N, 11.36.

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#### EXAMPLE 1d

##### Methyl-4-[(2-[N,N-bis-methylsulfonamidol]phenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate hydrochloride

25 To a solution of the compound d (0.70 g, 1.94 mmol) and triethylamine(0.44 mL, 3.19 mmol) in CH<sub>2</sub>Cl<sub>2</sub>(10.0 mL) at 0°C was added methanesulfonyl chloride(0.247 mL, 3.19 mmol). The reaction was stirred for 16 hr. The reaction was diluted with CH<sub>2</sub>Cl<sub>2</sub>(20.0 mL), washed with saturated NaHCO<sub>3</sub> solution and water. Then, dried over Mg<sub>2</sub>SO<sub>4</sub>. Then, isolated on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (98:2:2) to give the desired product as a free base (0.7 g, 70 %). Evaporate the solvent and generate an HCl salt(0.75 g; m.p. 145-150°C). <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.76 (4H, m), 2.2 (1H, m), 2.5-3.1 (6H, m), 3.44 (3H, s), 3.49 (3H, s), 3.71 (3H, s), 3.8-4.5(5H, m), 4.50 (1H, m), 4.89 (1H, m), 7.23-7.75(3H, Ar). MS (FAB) m/z 517. Anal. Calc. For C<sub>21</sub>H<sub>32</sub>N<sub>4</sub>O<sub>3</sub>S<sub>2</sub>.HCl: C, 46.05; H, 6.22; N, 10.09. Found: C, 45.60; H, 6.01; N, 10.13.

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#### EXAMPLE 1e

##### Methyl-4-[(2-[N-methylamino)sulfamyl]phenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl)methyl]-1-piperazinecarboxylate hydrochloride

40 The compound was prepared from (N-methylamino)sulfamyl phenyl acetic acid (a mixture of the ortho and para isomer) following Procedure A and isolated on a silica gel column [solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (99:2:1): R<sub>f</sub> = 0.56] to give the desired product as a free base (0.70g, 70 %). Then, generate the HCl salt(m.p. 155-160°C; 0.31 g). <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.75 (m, 4H), 2.53 (m, 4H), 2.66 (d, J=5.2 Hz, 3H), 2.82 (m, 3H), 3.25 (m, 1H), 3.72 (s, 3H), 3.84 (m, 2H), 4.15 (m, 2H), 4.50 (m, 1H), 4.85 (m, 1H), 7.45 (dd, J = 4.0, 8.2 Hz, 2H) 7.79 (d, J = 8.0 Hz, 1H), 7.83 (d, J= 8.2 Hz, 1H); MS(FAB) m/z 439. Anal. Calc. For C<sub>20</sub>H<sub>30</sub>N<sub>4</sub>O<sub>3</sub>S.HCl: C, 50.13; H, 6.61; N, 11.36. Found: C, 50.57; H, 6.58; N, 11.79.

**EXAMPLE 1f****Methyl-4-[-4-[N-methylamino)sulfamyl]phenyl]acetyl]-3-(R,S)-[(1-pyrrolidinyl) methyl]-1-piperazinecarboxylate hydrochloride**

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The compound was isolated from the above reaction on a silica gel column[solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (99:1:2) : R<sub>f</sub> = 0.62] to give the desired product as a free base. Then, generate the HCl salt(m.p. 135-140°C; 6.0 mg). <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.74 (m, 4H), 2.53 (m, 4H), 2.66 (d, J=5.2 Hz, 3H), 2.82 (m, 3H), 3.25 (m, 1H), 3.71 (s, 3H), 3.84 (m, 2H), 4.15 (m, 2H), 4.50 (m, 1H), 4.85 (m, 1H), 7.48 (m, 2H, ArH) 7.73 (m, 2H, ArH); MS(FAB) m/z 439. Anal. Calc. For C<sub>20</sub> H<sub>30</sub> N<sub>4</sub> O<sub>5</sub> S.HCl: C, 50.13; H, 6.61; N, 11.36. Found: C, 50.57; H, 6.58; N, 11.7.

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**EXAMPLE 1g**

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**4-Trifluoroacetyl-1-[(trans-3-furanacrylate)-2-(R,S)-(1-pyrrolidinyl) methyl] piperazine hydrochloride**

**4-Trifluoroacetyl-2-(R,S)-(1-pyrrolidinyl)methyl piperazine(e):** To a solution of (R,S)2-(1-pyrrolidinyl)methyl] piperazine hydrochloride (1.0 g, 3.58 mmol) and Et<sub>3</sub>N (0.5 mL, 3.58 mmol) in 10 mL of CH<sub>2</sub>Cl<sub>2</sub> was added trifluoroacetic anhydride (0.5 mL, 3.58 mmol) at 0°C. The reaction mixture is stirred at 0°C for 5 h. The reaction mixture was evaporated under reduced pressure (due to the water solubility of this compound there was no aqueous work-up) and isolated on a silica gel column (solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (98:2:2) to give the desired product as a free base (0.18 g, 20 %); <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.76 (m, 4H), 2.25-3.15 (m, 10H), 3.26 (t, 2H), 3.88 (m, 1H), 4.39 (t, 1H).

To a solution of trans-3-furanacrylic acid (0.10 g, 0.74 mmol) in 5 mL of dry CH<sub>2</sub>Cl<sub>2</sub> under a nitrogen atmosphere was added HOBt (0.10 g, 0.74 mmol). The reaction mixture is stirred at 0°C and added solid EDCI (0.143 g, 0.75 mmol). Then, stirred for 30 minutes at 0°C. A solution of compound e (0.18 g, 0.67 mmol) in 5 mL of dry CH<sub>2</sub>Cl<sub>2</sub> was added followed by DIEA (0.177 mL, 1.01 mmol). The reaction mixture was stirred for 24 h while warming to room temperature. The reaction mixture was then poured into water (50 mL) and stirred for 30 minutes. After dilution with CH<sub>2</sub>Cl<sub>2</sub>, the organic layer was separated, washed with saturated NaHCO<sub>3</sub>, salt solution, and water. Then, dried over MgSO<sub>4</sub>. The compound was purified by flash column chromatography on silica gel, eluting with CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH(99:1:2) to give the desired product as a free base(m.p. 144-145°C; 0.25 g, 95% yield). The hydrochloride salt was prepared from 1M ethereal HCl.(0.1 g) <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.74 (m, 4H), 2.57 (m, 5H), 3.11 (m, 2H), 3.31 (m, 2H), 4.05 (m, 1H), 4.25 (m, 1H), 4.50 (m, 1H), 4.65 (m, 1H), 6.58 (d, J = 3.3, 7.8 Hz, 2H), 7.44 (m, 1H), 7.64 (d, J=3.3Hz, 2H); MS (FAB) m/z 386; Anal. Calcd. For C<sub>18</sub> H<sub>22</sub> N<sub>3</sub> F<sub>3</sub> O<sub>3</sub>.HCl: C, 51.25; H, 5.50; N, 9.96. Found: C, 51.44; H, 5.57; N, 9.86.

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**EXAMPLE 1h****4-Trifluoroacetyl-1-[-(4-trifluoromethylphenyl)acetyl]-2-(R,S)-(1-pyrrolidinyl) methyl] piperazine hydrochloride**

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To a solution of 4-trifluoromethyl-phenyl acetic acid (0.08g, 0.39 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (5.0 mL) was added 1,1'-carbonyldiimidazole (0.06 g, 0.39 mmol) under a nitrogen

atmosphere and stirred for 1 h. Cool to 0°C and compound e (0.1 g, 0.39 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (5.0 mL) was added. Then, stirred for 16 h and the reaction mixture was then poured into a solution of ice-cold saturated NaHCO<sub>3</sub> and stirred for 30 minutes. After dilution with CH<sub>2</sub>Cl<sub>2</sub>, the organic layer was separated, washed with saturated salt solution, and dried over MgSO<sub>4</sub>. The compound was purified by flash column chromatography on silica gel, eluting with CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH(99:1:2) to give the desired product as a free base(m.p. 140-145 °C;0.08 g, 47% yield). The hydrochloride salt was prepared from 1M ethereal HCl.(0.05 g) <sup>1</sup>H NMR (free base 200MHz, CDCl<sub>3</sub>) δ 1.75 (m, 4H), 2.55 (m, 5H), 2.69-3.2 (m, 4H), 3.8 (m, 1H), 3.83 (m, 2H), 4.50 (m, 1H), 4.65 (m, 1H), 7.38 (d, J = 7.7 Hz, 2H), 7.64 (d, J= 7.8 Hz, 2H); MS (FAB) m/z 452; Anal. Calcd. For C<sub>20</sub> H<sub>23</sub> N<sub>3</sub> F<sub>3</sub> O<sub>2</sub>.HCl.0.3Et<sub>2</sub>O: C, 49.96; H, 5.30; N, 8.24. Found: C, 49.62; H, 5.16; N, 7.84.

#### EXAMPLE 1i

**Methyl-4-[(3,4-dichlorophenyl)acetyl]-3-(R,S)-[(4'-methylpiperazinecarboxylate)methyl]-1-piperazinecarboxylate hydrochloride**

The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with methyl-3 (R,S)-[(4'-methylpiperazinecarboxylate)methyl]-1-piperazinecarboxylate; mp: (HCl salt)160-165°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.5-1.8 (2H, m), 2.2-3.2 (8H, m), 3.3-3.5 (5H, m), 3.6 (3H, s), 3.7 (3H, s), 3.9-4.5 (3H, m), 4.7-4.8 (1H, m), 7.1 (1H, m), 7.4 (2H, m); MS (FAB) 487 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>21</sub>H<sub>28</sub>Cl<sub>2</sub>N<sub>4</sub>O<sub>5</sub>.HCl. H<sub>2</sub>O: C, 46.55; H, 5.77; N, 10.34. Found: C, 46.02; H, 5.93; N, 10.91.

#### EXAMPLE 1j

**Methyl-4-[(4-α,α,α-trifluoromethylphenyl)acetyl]-3-(R,S)-[3-(S)-(4'-α,α,α-trifluoromethylphenylacetate)-1-(pyrrolidinyl)methyl]-1-piperazinecarboxylate hydrochloride (1j)**

The compound was prepared by coupling of 4-α,α,α-trifluoromethylphenyl- acetic acid with methyl-3-(R,S)-[3-(S)-hydroxy-1-(pyrrolidinyl)methyl]-1-piperazine carboxylate; mp: (HCl salt)98-100°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.6-3.1 (11H, m), 3.4-5.4 (12H, m), 7.1-7.7 (8H, m); MS (FAB) 616 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>39</sub>H<sub>31</sub>F<sub>6</sub>N<sub>3</sub>O<sub>5</sub>.HCl. H<sub>2</sub>O.0.25NH<sub>4</sub>Cl: C, 50.97; H, 5.16; N, 6.66. Found: C, 50.45; H, 5.07; N, 6.67.

#### EXAMPLE 1k

**Methyl-4-[(3,4-dichlorophenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidinemethyl-3',4'-dichlorophenyl acetate)methyl]-1-piperazinecarboxylate hydrochloride**

The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with methyl-3-(R,S)-[(2-(S)-pyrrolidinemethanol)methyl]-1-piperazinecarboxylate; mp: (HCl salt)77-80°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.3-2.0 (5H, m), 2.0-2.5 (4H, m), 2.5-3.3 (5H, m), 3.7 (3H, s), 3.4-4.8 (3H, m), 3.8-4.9 (5H, m), 7.0 (2H, m), 7.3 (4H, m); MS (FAB) 632 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>30</sub>H<sub>33</sub>F<sub>6</sub>N<sub>3</sub>O<sub>4</sub>.

**EXAMPLE 1i****Methyl-4-[(3,4-dichlorophenyl)acetyl]-3-(R)-[(2-(S)-pyrrolidinemethanol)methyl]-1-piperazinecarboxylate hydrochloride**

The compound was prepared by aq. LiOH hydrolyzation of **1k**; mp: (HCl salt) 135-138°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.6-1.8 (4H, m), 3.7 (3H, s), 2.0-4.1 (15H, m), 4.3-4.8 (2H, m), 7.0 (1H, m), 7.3 (1H, m); MS (FAB) 444 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>20</sub>H<sub>27</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>4</sub>.HCl.H<sub>2</sub>O: C, 48.16; H, 6.06; N, 8.42. Found: C, 48.64; H, 6.05; N, 8.45.

**EXAMPLE 1m****Methyl-4-[(2-nitro-4-α,α,α-trifluoromethylphenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidine methanol)methyl]-1-piperazinecarboxylate hydrochloride**

The compound was prepared by aq. LiOH hydrolyzation of methyl-4-[(2-nitro-4-α,α,α-trifluoromethylphenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidine methyl-2'-nitro-4'-α,α,α-trifluoromethylphenyl)acetate)methyl]-1-piperazinecarboxylate; mp: (HCl salt) 136-140°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.6-1.9 (3H, m), 3.7 (3H, d), 2.1-3.6 (12H, m), 3.9-4.9 (6H, m), 7.4 (1H, d), 7.8 (1H, d), 8.3 (1H, s); MS (FAB) 489 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>21</sub>H<sub>27</sub>F<sub>3</sub>N<sub>3</sub>O<sub>6</sub>.HCl: C, 48.05; H, 5.38; N, 10.67. Found: C, 47.81; H, 5.27; N, 10.49.

**EXAMPLE 1n****Methyl-4-[(4-methylsulphonylphenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidinemethyl-4'-methylsulphonylphenyl)acetate)methyl]-1-piperazinecarboxylate hydrochloride**

The compound was prepared by coupling of 4-methylsulphonylphenylacetic acid with methyl-3-(R,S)-[(2-(S)-pyrrolidinemethanol)methyl]-1-piperazinecarboxylate; mp: (HCl salt) 133-135°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.4-2.5 (5H, m), 3.0 (3H, s), 2.6-3.3 (8H, m), 3.4-4.9 (15H, m), 7.4 (4H, m), 7.9 (4H, m); MS (FAB) 650 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>30</sub>H<sub>39</sub>S<sub>2</sub>N<sub>3</sub>O<sub>9</sub>.HCl.0.75NH<sub>4</sub>Cl: C, 49.61; H, 5.97; N, 7.23. Found: C, 50.07; H, 6.17; N, 7.26.

**EXAMPLE 1o****Methyl-4-[(4-methylsulphonylphenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidinemethanol)methyl]-1-piperazinecarboxylate hydrochloride**

The compound was prepared by aq. LiOH hydrolyzation of compound **1n**; mp: (HCl salt) 130-135°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.6-1.9 (4H, m), 2.1-2.5 (2H, m), 2.5-3.4 (7H, m), 3.0 (3H, s), 3.4-4.2 (6H, m), 3.7 (3H, m), 4.2-5.0 (2H, m), 7.5 (2H, m), 7.9 (2H, m); MS (FAB) 454 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>21</sub>H<sub>31</sub>SN<sub>3</sub>O<sub>6</sub>.HCl.H<sub>2</sub>O: C, 49.65; H, 6.75; N, 8.27. Found: C, 50.19; H, 6.77; N, 8.26.

**EXAMPLE 1p**

**Methyl-4-[(2-amino-4- $\alpha,\alpha,\alpha$ -trifluoromethylphenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidine methanol)methyl]-1-piperazinecarboxylate hydrochloride**

The compound was prepared by Pd catalyzed hydrogenation of compound 1m; mp: (HCl salt) 140-143°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>)  $\delta$  1.7-3.3 (12H, m), 3.7 (3H, s), 3.3-4.3 (11H, m), 6.9 (2H, m), 7.1 (1H, m); MS (FAB) 459 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>21</sub>H<sub>29</sub>F<sub>3</sub>N<sub>4</sub>O<sub>4</sub>·2HCl·CH<sub>3</sub>OH: C, 46.90; H, 6.26; N, 9.94. Found: C, 46.96; H, 6.14; N, 9.93.

**EXAMPLE 1q**

**Methyl-4-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[3-(S)-(3',4'-dichlorophenyl acetate)-1-(pyrrolidinyl)methyl]-1-piperazinecarboxylate hydrochloride**

The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with methyl-3-(R,S)-[3-(S)-hydroxy-1-(pyrrolidinyl)methyl]-1-piperazine carboxylate; mp: (HCl salt) 125-128°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>)  $\delta$  1.9-3.1 (9H, m), 3.4-3.8 (8H, m), 4.0-4.2 (3H, m), 4.5-5.2 (3H, m), 7.1 (2H, m), 7.4 (4H, m); MS (FAB) 618 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>27</sub>H<sub>29</sub>Cl<sub>4</sub>N<sub>3</sub>O<sub>5</sub>·HCl: C, 49.60; H, 4.62; N, 6.43. Found: C, 49.39; H, 4.65; N, 6.44.

**EXAMPLE 1r**

**4-Acetyl-1-[3-(N-methylsulfonamido)phenyl]acetyl-2-(R,S)-[(1-pyrrolidinyl) methyl]piperazine hydrochloride**

The compound was prepared by methylsulphonylation of 4-acetyl-1-[3-amino)phenyl]acetyl-2-(R,S)-[(1-pyrrolidinyl) methyl]piperazine as clear oil, the dihydrochloride salt was prepared from 1M etherial HCl; mp: (HCl salt) 140°C(dec.); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>)  $\delta$  1.5-1.7 (4H, m), 1.8-3.1 (13H, m), 3.4-4.9 (9H, m), 6.5 (2H, m), 7.0 (2H, m); MS (FAB) 423 (M + H)<sup>+</sup>. Anal. Calcd. for C<sub>20</sub>H<sub>30</sub>N<sub>4</sub>O<sub>4</sub>S·HCl·NH<sub>4</sub>Cl: C, 46.87; H, 6.88; N, 13.67. Found: C, 44.83; H, 7.18; N, 13.16.

**EXAMPLE 1s**

**4-Acetyl-1-[(2-acetylamidophenyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl) methyl] piperazine hydrochloride**

The compound was prepared by acetylation of 4-acetyl-1-[(2-aminophenyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl]piperazine; mp: (HCl salt) 173°C(dec.); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>)  $\delta$  1.3-1.8 (6H, m), 2.0 (3H, s), 2.1 (3H, s), 2.2-3.4 (8H, m), 3.6-4.8 (6H, m), 6.9-7.2 (3H, m), 7.8 (1H, m); MS (FAB) 387 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>21</sub>H<sub>30</sub>N<sub>4</sub>O<sub>5</sub>·HCl·2H<sub>2</sub>O: C, 54.95; H, 7.69; N, 12.21. Found: C, 54.53; H, 6.91; N, 11.92.

**EXAMPLE 1t****4-Acetyl-1-[(4-acetylamidophenyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl] piperazine hydrochloride**

The compound was prepared by acetylation of 4-acetyl-1-[(4-aminophenyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl]piperazine; mp: (HCl salt) 165°C(dec.); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.5-1.7 (5H, m), 1.9-2.1 (6H, m), 2.2-3.1 (8H, m), 3.5-4.7 (6H, m), 7.0 (2H, m), 7.4 (2H, m); MS (FAB) 387 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>21</sub>H<sub>30</sub>O<sub>3</sub>N<sub>4</sub>·HCl·H<sub>2</sub>O: C, 57.20; H, 7.54; N, 12.71. Found: C, 57.05; H, 7.31; N, 12.74.

**EXAMPLE 1u****4-Acetyl-1-(4-methylsulfonylphenyl)acetyl]-2-(R,S)-[3-(S)-(4'-methylsulfonyl phenyl acetate)-1-(pyrrolidinyl)methyl] piperazine hydrochloride**

The compound was prepared by coupling of 4-methylsulfonylphenylacetic acid with 4-acetyl-2-(R,S)-[3-(S)-hydroxy-1-(pyrrolidinyl)methyl] piperazine; mp: (HCl salt) 160-163°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.7-2.2 (7H, m), 2.3-3.2 (12H, m), 3.0 (6H, s), 3.5-4.1 (8H, m), 4.4-5.2 (4H, m), 7.4 (4H, m), 7.8 (4H, m); MS (FAB) 620 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>29</sub>H<sub>37</sub>S<sub>2</sub>N<sub>3</sub>O<sub>8</sub>·HCl: C, 53.00; H, 5.98; N, 6.39. Found: C, 52.26; H, 6.00; N, 6.37.

**EXAMPLE 1v****4-Acetyl-1-[(4-α,α,α-trifluoromethylphenyl)acetyl]-2-(R,S)-[3-(S)-(4'-α,α,α trifluoro methylphenyl acetate)-1-(pyrrolidinyl)methyl] piperazine hydrochloride**

The compound was prepared by coupling of 4-α,α,α-trifluoromethylphenyl acetic acid with 4-acetyl-2-(R,S)-[3-(S)-hydroxy-1-(pyrrolidinyl)methyl] piperazine; mp: (HCl salt) 134-136°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.6-3.2 (15H, m), 3.4-4.1 (5H, m), 4.3-5.2 (3H, m), 7.3 (4H, m), 7.5 (4H, m); MS (FAB) 599 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>29</sub>H<sub>31</sub>F<sub>6</sub>N<sub>3</sub>O<sub>4</sub>·HCl·0.5NH<sub>4</sub>Cl: C, 52.55; H, 5.17; N, 7.40. Found: C, 52.05; H, 5.56; N, 7.90.

**EXAMPLE 1w****4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[3-(S)-(3',4'-dichlorophenyl acetate)-1-(pyrrolidinyl)methyl]piperazine hydrochloride**

The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with 4-acetyl-2-(R,S)-[3-(S)-hydroxy-1-(pyrrolidinyl)methyl] piperazine; mp: (HCl salt) 122-125°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.6-1.9 (3H, m), 2.1 (3H, s), 2.1-3.9 (14H, m), 4.0-5.3 (3H, m), 7.1 (2H, m), 7.4 (4H, m); MS (FAB) 602 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>27</sub>H<sub>29</sub>Cl<sub>4</sub>N<sub>3</sub>O<sub>4</sub>·HCl: C, 50.84; H, 4.74; N, 6.59. Found: C, 49.33; H, 4.76; N, 6.85.



**EXAMPLE 1x****4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-  
[(2-(S)-pyrrolidinemethyl-3',4' dichlorophenylacetate)methyl]  
piperazine hydrochloride**

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The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with 4-acetyl-2-(R,S)-[(2-(S)-pyrrolidinemethanol)methyl]piperazine; mp: (HCl salt) 107-110°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.5-2.0 (3H, m), 2.0-2.2 (3H, d), 2.2-3.3 (9H, m), 3.5-4.1 (8H, m), 4.4-4.9 ((2H, m), 7.1 (2H, m), 7.4 (4H, m); MS (FAB) 616 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>28</sub>H<sub>31</sub>Cl<sub>4</sub>N<sub>3</sub>O<sub>4</sub>.HCl.NH<sub>4</sub>Cl: C, 47.68; H, 5.14; N, 7.94. Found: C, 47.80; H, 5.38; N, 9.05.

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**EXAMPLE 1y**

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**4-Acetyl-1-[(4-trifluoromethylphenyl)acetyl]-2-(R,S)-[2-(S)-pyrrolidinemethyl-4'-  
trifluoromethylphenylacetate)methyl]piperazine hydrochloride**

The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with 4-acetyl-2-(R,S)-[(2-(S)-pyrrolidinemethanol)methyl]piperazine; mp: (HCl salt) 110-113°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.5-3.3 (12H, m), 2.1 (3H, s), 3.5-4.1 (9H, m), 4.3-4.9 (1H, m), 7.3 (4H, m), 7.5 (4H, m); MS (FAB) 614 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>30</sub>H<sub>33</sub>F<sub>6</sub>N<sub>3</sub>O<sub>4</sub>.HCl.0.5NH<sub>4</sub>Cl: C, 53.24; H, 5.36; N, 7.24. Found: C, 53.86; H, 5.45; N, 6.91.

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**EXAMPLE 1z****4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[(2-(S)-pyrrolidine  
methanol) methyl]piperazine hydrochloride**

The compound was prepared by aq. LiOH hydrolyzation of compound 1x; mp: (HCl salt) 123-125°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.6-2.0 (4H, m), 2.1 (3H, m), 2.2-3.4 (10H, m), 3.4-4.0 (5H, m), 4.4-5.0 (2H, m), 7.1 (2H, m), 7.4 (2H, m); MS (FAB) 428 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>20</sub>H<sub>27</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>3</sub>.HCl: C, 51.68; H, 6.07; N, 9.04. Found: C, 49.84; H, 6.08; N, 9.03.

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**EXAMPLE 1aa****4-Acetyl-1-[(4-methylsulphonylphenyl)acetyl]-2-(R,S)-[(2-(S)-pyrrolidinemethyl-4'-  
methylsulphonylphenylacetate)methyl]piperazine hydrochloride**

The compound was prepared by coupling of 4-methylsulphonylphenylacetic acid with 4-acetyl-2-(R,S)-[(2-(S)-pyrrolidinemethanol)methyl]piperazine; mp: (HCl salt) 145-148°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.5-2.0 (3H, m), 2.1 (3H, m), 3.0 (6H, s), 2.5-3.3 (9H, m), 3.6-4.2 (9H, m), 4.5 (1H, m), 7.5 (4H, m), 7.9 (4H, m); MS (FAB) 634 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>30</sub>H<sub>39</sub>S<sub>2</sub>N<sub>3</sub>O<sub>8</sub>.HCl.0.25NH<sub>4</sub>Cl: C, 52.71; H, 6.05; N, 6.66. Found: C, 52.02; H, 6.19; N, 6.59

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**EXAMPLE 1bb****4-Acetyl-1-[(4-methylsulphonylphenyl)acetyl]-2-(R,S)-[(2-(S)-pyrrolidinemethanol)methyl]piperazine hydrochloride**

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The compound was prepared by aq. LiOH hydrolyzation of compound 1aa; mp: (HCl salt) 138-140°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.6-2.0 (4H, m), 2.1 (3H, m), 2.2-3.0 (5H, m), 3.1 (3H, s), 3.1-4.0 (10H, m), 4.4-5.0 (2H, m), 7.5 (2H, m), 7.9 (2H, m); MS (FAB) 438 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>21</sub>H<sub>31</sub>SN<sub>3</sub>O<sub>5</sub>·HCl·H<sub>2</sub>O: C, 51.26; H, 6.96; N, 8.54. Found: C, 50.36; H, 6.92; N, 8.90.

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**EXAMPLE 1cc****4-Acetyl-1-[(4-trifluoromethylphenyl)acetyl]-2-(R,S)-[(2-(S)-pyrrolidinemethanol)methyl]piperazine hydrochloride**

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The compound was prepared by aq. LiOH hydrolyzation of compound 1y; mp: (HCl salt) 123-125°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.6-2.2 (4H, m), 2.1 (3H, s), 2.2-4.0 (15H, m), 4.5-5.0 (2H, m), 7.4 (2H, m), 7.6 (2H, m); MS (FAB) 428 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>21</sub>H<sub>28</sub>F<sub>3</sub>N<sub>3</sub>O<sub>3</sub>·HCl·NH<sub>4</sub>Cl: C, 48.75; H, 6.43; N, 10.83. Found: C, 47.46; H, 6.04; N, 12.40.

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**EXAMPLE 1dd****4-Formyl-1-[(2-N-methylsulfonylphenyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl]piperazine hydrochloride**

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The compound was prepared by coupling of 2-(N-methylaminosulfonyl)phenyl acetic acid with 4-formyl-2-(R,S)-[(1-pyrrolidinyl)methyl] piperazine; mp: (HCl salt) 150°C(dec.); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.7 (4H, m), 2.2-3.2 (11H, m), 3.4-4.0 (4H, m), 4.2-5.4 (4H, m), 7.0 (1H, m), 7.4 (2H, m), 7.6 (1H, ), 8.0 (1H, m); MS (FAB) 409 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>19</sub>H<sub>28</sub>O<sub>4</sub>N<sub>4</sub>S·HCl·0.5NH<sub>4</sub>Cl: C, 48.38; H, 6.62; N, 13.36. Found: C, 48.08; H, 6.46; N, 13.33.

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**EXAMPLE 1ee****4-Carbonylimidazole-1-[(3,4-dichlorophenyl)acetyl]-2-(R)-[(1-pyrrolidinyl)methyl]piperazine hydrochloride**

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The compound was prepared by coupling of 1,1'-carbonyldiimidazole with 1-[(3,4-dichlorophenyl)acetyl]-2-(R)-[(1-pyrrolidinyl)methyl] piperazine; mp: (HCl salt) 148°C(dec.); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.5-1.7 (4H, m), 2.1-2.5 (5H, m), 2.6-3.4 (4H, m), 3.5-4.8 (7H, m), 6.9-7.4 (4H, m), 8.0 (1H, m); MS (FAB) 450 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>21</sub>H<sub>25</sub>Cl<sub>2</sub>N<sub>5</sub>O<sub>2</sub>·2HCl·H<sub>2</sub>O: C, 46.60; H, 5.40; N, 12.94. Found: C, 45.41; H, 5.33; N, 12.73.

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**EXAMPLE 1ff****4-Allyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R)-[(1-pyrrolidinyl)methyl]piperazine hydrochloride**

5 The compound was prepared by coupling of allyl bromide with 1-[(3,4-dichlorophenyl)acetyl]-2-(R)-[(1-pyrrolidinyl)methyl] piperazine in 81% yield; mp: (HCl salt) 157-160°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.4-2.0 (6H, m), 2.3-3.0 (6H, m), 3.1-3.8 (4H, m), 4.3-4.8 (1H, m), 4.9-5.1 (2H, m), 5.7-5.9 (1H, m), 7.0-7.3 (3H, m); MS (FAB) 396 (M + H)<sup>+</sup>; Anal. Calcd for C<sub>20</sub>H<sub>27</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>2</sub>.2HCl: C, 51.19; H, 6.23; N, 8.95. Found: C, 50.89; H, 6.42; N, 8.65.

**EXAMPLE 1gg****4-Acetyl-1-[(2-pyridyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl] piperazine hydrochloride**

15 The compound was prepared by coupling of 2-pyridylacetic acid with 4-acetyl-2-(R,S)-[(1-pyrrolidinyl)methyl] piperazine; mp: (HCl salt) 127-130°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.4-1.7 (4H, m), 2.0 (3H, s), 2.2-3.2 (9H, m), 3.4-4.8 (6H, m), 6.8-7.5 (3H, m), 8.4 (1H, m); MS (FAB) 331 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>18</sub>H<sub>26</sub>N<sub>4</sub>O<sub>2</sub>.2HCl. 0.5NH<sub>4</sub>Cl: C, 50.27; H, 7.03; N, 14.65. Found: C, 50.86; H, 6.47; N, 15.79.

**EXAMPLE 1hh****4-Formyl-1-[(2-pyridyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl] piperazine hydrochloride**

25 The compound was prepared by coupling of 2-pyridylacetic acid with 4-formyl-2-(R,S)-[(1-pyrrolidinyl)methyl]piperazine; mp: (HCl salt) 125-128°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.5-1.7 (4H, m), 2.1-3.6 (10H, m), 3.7-4.9 (5H, m), 6.9-7.3 (2H, m), 7.6 (1H, m), 8.0 (1H, m), 8.6 (1H, m); MS (FAB) 317 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>17</sub>H<sub>24</sub>N<sub>4</sub>O<sub>2</sub>.2HCl.NH<sub>4</sub>Cl: C, 46.11; H, 6.83; N, 15.82. Found: C, 46.37; H, 6.51; N, 16.35.

**EXAMPLE 1ii****Methyl-4-[(3,4-dichlorophenyl)acetyl]-3-(S)-[(2-(S)-pyrrolidinemethanol)methyl]-1-piperazinecarboxylate hydrochloride**

40 The compound was prepared by aq. LiOH hydrolyzation of 1k; mp: (HCl salt) 137-140°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.5-2.0 (4H, m), 3.7 (3H, s), 2.1-3.7 (14H, m), 3.8-4.9 (3H, m), 7.1 (1H, m), 7.3 (2H, m); MS (FAB) 444 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>20</sub>H<sub>27</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>4</sub>.HCl. 0.5NH<sub>4</sub>Cl: C, 47.33; H, 5.96; N, 9.66. Found: C, 47.55; H, 6.11; N, 9.39.

**EXAMPLE 1jj****4-Methanesulfonyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[3-(S)-methanesulfonate-1-(pyrrolidinyl) methyl]piperazine hydrochloride**

5 The compound was prepared from 1-[(3,4-dichlorophenyl)acetyl]-2-[(3-hydroxy-1-pyrrolidinyl)methyl]piperazine dihydrochloride<sup>1</sup> (0.25 g, 0.56 mmol), methanesulfonyl chloride (0.43 mL, 5.56 mmol), triethylamine (2.3 mL, 16.53 mmol) and CH<sub>2</sub>Cl<sub>2</sub> (20 mL) at 0°C for 6 h. After dilution with saturated NaHCO<sub>3</sub> solution (20 mL) and washed with water (20 mL). Then, dried over Mg<sub>2</sub>SO<sub>4</sub>. The compound was purified by flash chromatography on silica gel, eluting with CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:28%NH<sub>4</sub>OH(99:1:2) to give the desired product as a free base (0.28 g; 94% yield) and a hydrochloride salt was generated (0.067 g; m.p. 130-132°C; <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 2.10(m, 1H), 2.29(m, 1H), 2.59(m, 4H), 2.89 (s, 3H), 3.01 (s, 3H), 3.2-3.5(m, 2H), 3.60-3.9(m, 4H), 4.90 (m, 1H), 5.15(m, 1H), 7.12(d, J=8.2 Hz, 1H), 7.43 (d, J= 8.3Hz, 2H); MS (FAB) 528 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>19</sub>H<sub>27</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>6</sub>S<sub>2</sub>.HCl: C, 40.40; H, 5.00; N, 7.44. Found: C, 40.29; H, 5.07; N, 7.04.

**EXAMPLE 1kk****4-Methylsulphonyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[3-(S)-(3',4'dichloro phenyl acetate)-1-(pyrrolidinyl)methyl]piperazine hydrochloride**

20 The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with 4-methylsulphonyl-2-(R,S)-[3-(S)-(hydroxy)-1-(pyrrolidinyl)methyl]piperazine; mp: (HCl salt) 145-148°C; <sup>1</sup>H NMR (freebase, 200 MHz, CDCl<sub>3</sub>) δ 1.5-1.9 (2H, m), 2.2-3.0 (7H, m), 2.7 (3H, s), 3.5-4.0 (8H, m), 4.9-5.2 (3H, m), 7.1 (2H, m), 7.4 (4H, m); MS (FAB) 638(M + H)<sup>+</sup>; Anal. Calcd. for C<sub>26</sub>H<sub>29</sub>Cl<sub>4</sub>N<sub>3</sub>O<sub>5</sub>S. HCl. 0.5NH<sub>4</sub>Cl: C, 44.52; H, 4.60; N, 7.00. Found: C, 45.66; H, 4.72; N, 7.61.

**EXAMPLE 1ll****4-Methylsulphonyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[3-(S)-hydroxy-1-pyrrolidinyl) methyl]piperazine hydrochloride**

30 The compound was prepared by aq. LiOH hydrolization of 1kk; mp: (HCl salt) 150-153°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.5-2.3(4H, m), 2.4-3.2 (7H, m), 2.8 (3H, s), 3.4-4.0 (5H, m), 4.5-5.2 (3H, m), 7.1(1H, m), 7.4 (2H, m); MS (FAB) 450 (M + H)<sup>+</sup>; Anal. Calcd. For C<sub>18</sub>H<sub>25</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>4</sub>S. HCl. 0.25NH<sub>4</sub>Cl: C, 43.22; H, 5.44; N, 9.10. Found: C, 43.23; H, 5.16; N, 9.8

**EXAMPLE 1mm****4-Methylsulphonyl-1-[(4-α,α,α-trifluoromethylphenyl)acetyl]-2-(R,S)-[3-(S)-(4'-α,α,α-trifluoro methylphenyl acetate)-1-(pyrrolidinyl) methyl]piperazine hydrochloride**

45 The compound was prepared by coupling of 4-(a,a,a-trifluoromethyl)phenyl acetic acid with 4-methyl sulphonyl-2-(R,S)-[3-(S)-hydroxy-1-(pyrrolidinyl) methyl] piperazine; mp:(HCl salt) 120-123°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.8-2.2 (4H, m), 2.4-3.3

(8H, m), 2.7 (3H, s), 3.6-4.0 (6H, m), 4.8-5.2 (2H, m), 7.4 (4H, m), 7.6 (4H, m); MS (FAB) 636 (M + H)<sup>+</sup>; Anal. Calcd. For C<sub>28</sub>H<sub>31</sub>F<sub>6</sub>N<sub>3</sub>O<sub>3</sub>S.HCl: C, 50.04; H, 4.80; N, 6.25. Found: C, 50.34; H, 4.80; N, 6.09.

5

#### EXAMPLE 1nn

##### 4-Methylsulphonyl-1-[(4- $\alpha,\alpha,\alpha$ -trifluoromethylphenyl)acetyl]-2-(R,S)- [(3-(S)-hydroxy-1-pyrrolidinyl)methyl] piperazine hydrochloride

10

The compound was prepared by aq. LiOH hydrolyzation of 1mm; mp: (HCl salt) 145°C(dec.); <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>)  $\delta$  1.5-2.1 (3H, m), 2.3-3.4 (9H, m), 2.8 (3H, s), 3.7-4.0 (5H, m), 4.3-5.0 (2H, m), 7.4 (2H, m), 7.6 (2H, m); MS (FAB) 450 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>19</sub>H<sub>26</sub>F<sub>3</sub>N<sub>3</sub>O<sub>4</sub>S.HCl: C, 46.96; H, 5.60; N, 8.65. Found: C, 46.45; H, 5.66; N, 8.69.

15

#### EXAMPLE 1oo

##### 4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(S)- [(3'-(S)-hydroxy-1-pyrrolidine)methyl]piperazine hydrochloride

20

The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with 4-acetyl-2-(R,S)-[(3'-(S)-hydroxypyrrolidine)methyl]piperazine. Then, this racemic mixture was separated on a Chiralpak AD column using 100% acetonitrile as the eluant. Then, from the 2-(S), 3'-(S) enantiomer a HCl salt was generated (1.0 gm.); mp: (HCl salt) 130-135°C; [a]<sub>D</sub><sup>20</sup> +25.56° (0.85%; w/v MeOH). <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>)  $\delta$  1.74 (1H, m), 2.13 (3H, s), 2.2 (1H, m), 2.3-3.2 (10H, m), 3.45-3.71 (3H, m), 4.11 (1H, d) 4.21-4.74 (2H, m), 4.55 (1H, m), 7.10 (1H, J= 8.25 Hz, d), 7.41 (2H, J= 8.28 Hz, d); MS (FAB) 414 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>19</sub>H<sub>23</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>3</sub>.HCl.0.5 H<sub>2</sub>O: C, 49.65; H, 5.77; N, 8.91. Found: C, 49.58; H, 5.65; N, 9.13.

30

#### EXAMPLE 1pp

##### 4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R)- [(3'-(R)-hydroxy-1-pyrrolidine)methyl]piperazine hydrochloride

35

The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with 4-acetyl-2-(R,S)-[(3'-(R)-hydroxy-1-pyrrolidine)methyl]piperazine. Then, this racemic mixture was separated on a Chiralpak AD column using 100% acetonitrile as the eluant. Then, from the 2-(R), 3'-(R) enantiomer a HCl salt was generated (0.9 gm.); mp: (HCl salt) 130-135°C; [a]<sub>D</sub><sup>20</sup> -30.49° (0.88%; w/v MeOH). <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>)  $\delta$  1.74 (1H, m), 2.13 (3H, s), 2.2 (1H, m), 2.3-3.2 (10H, m), 3.45-3.71 (3H, m), 4.11 (1H, d) 4.21-4.74 (2H, m), 4.55 (1H, m), 7.10 (1H, J= 8.25 Hz, d), 7.41 (2H, J= 8.28 Hz, d); MS (FAB) 414 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>19</sub>H<sub>23</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>3</sub>.HCl: C, 50.62; H, 5.81; N, 9.32. Found: C, 49.94; H, 5.84; N, 8.97.

45

**EXAMPLE 1qq****4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(S)-  
[(3'-(R)-hydroxy-1-pyrrolidine)methyl]piperazine hydrochloride**

5 The compound was prepared by coupling of 3,4-dichlorophenylacetic acid with 4-acetyl-2-(R,S)-[(3'-(R)-hydroxy-1-pyrrolidine)methyl]piperazine. Then, this racemic mixture was separated on a Chiralpak AD column using 100% acetonitrile as the eluant. Then, from the 2-(S), 3'-(R) enantiomer a HCl salt was generated (1.05 gm); mp: (HCl salt) 130-135°C; [a]<sup>20</sup> +28.8° (0.75%; w/v MeOH). <sup>1</sup>H NMR (free base, 300 MHz, CDCl<sub>3</sub>) δ 1.74 (1H, m),  
10 2.13 (3H, s), 2.2 (1H, m), 2.3-3.2 (10H, m), 3.45-3.71 (3H, m), 4.11 (1H, d) 4.21-4.74 (2H, m), 4.55 (1H, m), 7.10 (1H, J= 8.25 Hz, d), 7.41 (2H, J= 8.28 Hz, d); MS (FAB) 414 (M + H)<sup>+</sup>; Anal. Calcd. for C<sub>19</sub>H<sub>25</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>3</sub>·HCl: C, 50.62; H, 5.81; N, 9.32. Found: C, 50.19; H, 5.86; N, 9.06.

15 **Ref.**

1. Naylor, A.; Judd, D. B.; Lloyd, J. E.; Scopes, D. I. C.; Hayes, A. G.; Birch, P. J. *J. Med. Chem.* 1993, 36, 2075-2083 and references cited in there.
2. U.S. Patent 5,116,842; Naylor et al; 1992.

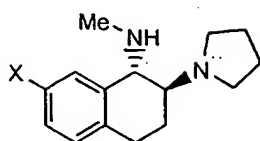
20

**Compounds of formula II**

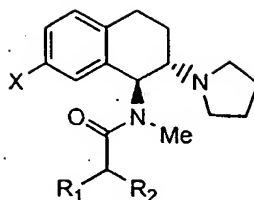
25 **General procedure for DCC/pyr coupling.** With stirring at 25°C under N<sub>2</sub>, DCC (2.06 eq) and CH<sub>2</sub>Cl<sub>2</sub> were added to a mixture of the acid (2 eq) and pyridine (2.06 eq) in CH<sub>2</sub>Cl<sub>2</sub>. After 1-2 min, a solution of the amine (1 eq) in CH<sub>2</sub>Cl<sub>2</sub> was added, and the mixture was stirred at 25°C under N<sub>2</sub> overnight. The final concentration of the mixture is around 0.1-0.3 mM with respect to the amine. Sat'd. NaHCO<sub>3</sub> (2 mL) was added to destroy excess  
30 active esters before the mixture was filtered through celite, and the DCU was washed with CH<sub>2</sub>Cl<sub>2</sub>. The filtrate was then partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>, which was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. Toluene was added to azeotrope off pyridine before the crude product was chromatographed and converted to the HCl salt.

35

Compounds having the following structures were prepared:



(±)-1, X=OMe  
(±)-2, X=NO<sub>2</sub>

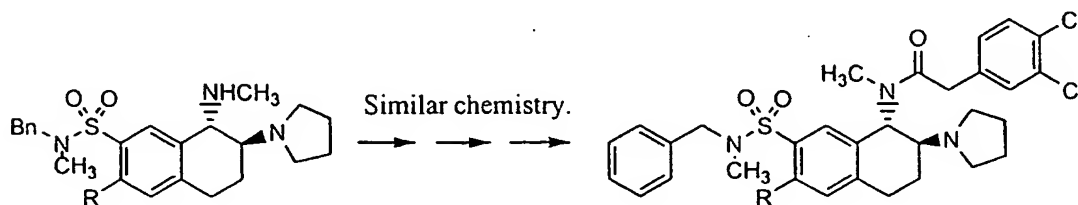


- (±)-3, ADL-01-0017-2, X=OMe, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-4, ADL-01-0018-0, X=OH, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-5, ADL-01-0019-8, X=OCH<sub>2</sub>CO<sub>2</sub>H, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-6, ADL-01-0020-6, X=OMe, R<sub>1</sub>=R<sub>2</sub>=phenyl  
 (±)-7, ADL-01-0021-4, X=OH, R<sub>1</sub>=R<sub>2</sub>=phenyl  
 (±)-8, ADL-01-0029-7, X=NO<sub>2</sub>, R<sub>1</sub>=H, R<sub>2</sub>=2-NO<sub>2</sub>-4,5-Cl<sub>2</sub>-phenyl  
 (±)-9, ADL-01-0031-3, X=NO<sub>2</sub>, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-10, ADL-01-0032-1, X=NH<sub>2</sub>, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-11, ADL-01-0034-7, X=NO<sub>2</sub>, R<sub>1</sub>=H, R<sub>2</sub>=4-methylsulfonylphenyl  
 (±)-12, ADL-01-0037-0, X=N(CH<sub>2</sub>CO<sub>2</sub>tBu)<sub>2</sub>, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-13, ADL-01-0044-6, X=N(CH<sub>2</sub>CO<sub>2</sub>H)<sub>2</sub>, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-14, ADL-01-0052-9, X=N(CH<sub>2</sub>CO<sub>2</sub>Et)<sub>2</sub>, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-15, ADL-01-0053-7, X=NHPO<sub>3</sub>Et<sub>2</sub>, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-16, ADL-01-0070-1, X=NH(CH<sub>2</sub>)<sub>2</sub>PO<sub>3</sub>Et<sub>2</sub>, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl

Intermediates (±)-1 and (±)-2 were prepared via reported methods from the appropriate starting materials.<sup>5</sup> Compounds (±)-3 and (±)-4 are known compounds prepared via reported methods.<sup>5</sup> Compounds (±)-5 through (±)-16 were prepared by DCC coupling of either (±)-1  
 5 or (±)-2 to an arylacetic acid followed by demethylation or reduction to allow peripheralization.

Ref.

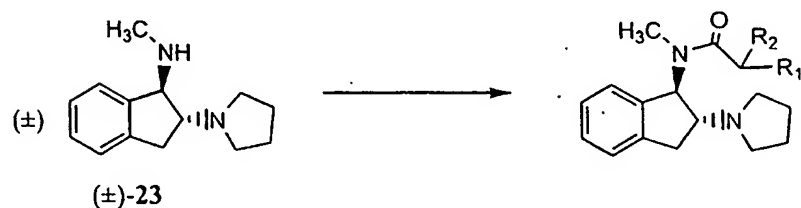
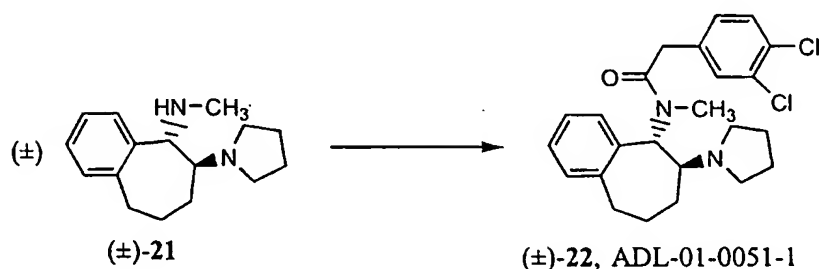
(5) Rajagopalan, P. et al. Bioorg. Med. Chem. Letters 1992, 2, 721-726.



(±)-17, R=OMe  
(±)-18, R=H

(±)-19, ADL-01-0090-9, R=OMe  
(±)-20, ADL-01-0099-0, R=H

Intermediates 17 and 18 were prepared via known methods from 6-methoxy-1-tetralone and 1-tetralone, respectively. Intermediates 17 and 18 were coupled to 3,4-dichlorophenylacetic acid to produce (±)-19 and (±)-20.



(±)-25, ADL-01-0105-5, R<sub>1</sub>=H, R<sub>2</sub>=3-NO<sub>2</sub>-phenyl  
 (±)-26, ADL-01-0106-3, R<sub>1</sub>=H, R<sub>2</sub>=2-NO<sub>2</sub>-4-CF<sub>3</sub>-phenyl  
 (±)-27, ADL-01-0107-1, R<sub>1</sub>=H, R<sub>2</sub>=3,4-Cl<sub>2</sub>-phenyl  
 (±)-28, ADL-01-0108-9, R<sub>1</sub>=phenyl, R<sub>2</sub>=phenyl  
 (±)-29, ADL-01-0109-7, R<sub>1</sub>=H, R<sub>2</sub>=4-methylsulfonylphenyl

- 5 Intermediates (±)-21 and (±)-23 were prepared via similar chemistry from 1-benzosuberone and (±)-trans-2-bromo-1-indanol. 1 Compounds (±)-22, (±)-25 (Niravoline),<sup>6</sup> and (±)-27 are known compounds prepared via reported chemistry. 1 Compounds (±)-24 through (±)-29 were prepared by DCC coupling to the appropriate arylacetic acid.

Ref.

- 10 (6) Bellissant, E. et al. J. Pharmacol. Exp. Ther. 1996, 278, 232-242.

Representative examples of formula II follow.

### Example 33

- 15 2-{7-[(±)-trans-1-(N-3,4-dichlorophenylacetamido)-N-methylamino]-2-(1-pyrrolidinyl)-1,2,3,4-tetrahydronaphthoxy}}acetic acid ((±)-5, ADL-01-0019-8)

- 20 With stirring at 25 °C under N<sub>2</sub>, t-butyl bromoacetate (0.35 mL, 2.38 mmol) was added to a mixture of (±)-4 (0.688 g, 1.59 mmol) and K<sub>2</sub>CO<sub>3</sub> (0.5 g, 3.6 mmol) in DMF (8 mL), and the mixture was stirred at 25 °C under N<sub>2</sub> overnight before the mixture was evaporated under high vacuum. The residue was partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub> (2 X 100 mL).



which was dried ( $\text{Na}_2\text{SO}_4$ ), filtered through celite, and evaporated. The t-butyl ester intermediate was flash column chromatographed twice eluting with  $\text{CH}_2\text{Cl}_2$ :2%  $\text{NH}_3$ :2% MeOH and  $\text{CH}_2\text{Cl}_2$ :2%  $\text{NH}_3$ :1% MeOH, respectively. The t-butyl ester was then deprotected in a mixture of THF (4 mL) and conc. HCl (2 mL) with stirring at 25 °C overnight and at 50 °C for 1h before the mixture was evaporated. The residue was then dissolved in a mixture of trifluoroacetic acid (2 mL), 4 N HCl (2 mL), and anisole (1 drop), and stirred at 25 °C for 2.5 days before the mixture was evaporated. The oily residue was triturated with  $\text{Et}_2\text{O}$  and sonicated to yield ( $\pm$ )-5HCl (0.259 g, 31%): m.p. (HCl salt) 138 °C (dec);  $^1\text{H}$  NMR (HCl salt, DMSO- $d_6$ )  $\delta$  1.7-2.1 (br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 2.2-4.8 (complex, 13H, 6  $-\text{CH}_2-$  and 1  $-\text{CH}-$ ), 2.79 (s, 3H,  $-\text{NCH}_3$ ), 5.98 (d,  $J$  = 10.3 Hz, 1H,  $-\text{CH}-$ ), 6.40 (s, 1H, aromatic), 6.82 (m, 1H, aromatic), 7.12 (d,  $J$  = 8.2 Hz, 1H, aromatic), 7.39 (d,  $J$  = 8.3 Hz, 1H, aromatic), 7.63 (m, 2H, aromatic). MS (FAB)  $m/z$  491. Anal. (C, H, N)  $\text{C}_{25}\text{H}_{28}\text{N}_2\text{O}_4\text{Cl}_2\cdot\text{HCl}$ .

### Example 34

#### 2,2-Diphenyl-N-methyl-N-[( $\pm$ )-trans-2-(1-pyrrolidiny)-7-methoxy-1,2,3,4-tetrahydronaphth-1-yl]acetamide (( $\pm$ )-6, ADL-01-0020-6)

ADL-01-0020-6 was prepared via the general DCC/pyr coupling method from ( $\pm$ )-1 (1.453 g, 5.58 mmol), diphenylacetic acid (2.369 g, 11.16 mmol), DCC (2.373 g, 11.50 mmol), and pyridine (0.93 mL, 11.5 mmol). The product was flash column chromatographed eluting with  $\text{CH}_2\text{Cl}_2$ :2%  $\text{NH}_3$ :1% MeOH before it was converted to the HCl salt with 1.0 M HCl in  $\text{Et}_2\text{O}$  and crystallized from MeOH- $\text{Et}_2\text{O}$  to yield ( $\pm$ )-6HCl (1.7 g, 63%): m.p. (HCl salt) >250 °C;  $^1\text{H}$  NMR (HCl salt, DMSO- $d_6$ )  $\delta$  1.8-2.0 (br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 2.2-3.9 (complex, 9H, 4  $-\text{CH}_2-$  and 1  $-\text{CH}-$ ), 2.79 (s, 3H,  $-\text{NCH}_3$ ), 3.48 (s, 3H,  $-\text{OCH}_3$ ), 5.66 (s, 1H,  $-\text{CH}-$ ), 6.1 (d,  $J$  = 9.4 Hz, 1H,  $-\text{CH}-$ ), 6.23 (s, 1H, aromatic), 6.77 (d of d,  $J$  = 2.4 Hz and 8.4 Hz, 1H, aromatic), 7.09 (d,  $J$  = 8.5 Hz, 1H, aromatic), 7.2-7.5 (complex, 10H, aromatic). MS (FAB)  $m/z$  455. Anal. (C, H, N)  $\text{C}_{30}\text{H}_{34}\text{N}_2\text{O}_2\cdot\text{HCl}$ .

### Example 35

#### 2,2-Diphenyl-N-methyl-N-[( $\pm$ )-trans-2-(1-pyrrolidiny)-7-hydroxy-1,2,3,4-tetrahydronaphth-1-yl]acetamide (( $\pm$ )-7, ADL-01-0021-4)

With stirring in dry ice-acetone under  $\text{N}_2$ , 1.0 M  $\text{BBr}_3$  in  $\text{CH}_2\text{Cl}_2$  (19.7 mL) was added at a fast drop rate to a solution of ( $\pm$ )-6 (1.491 g, 3.28 mmol) in  $\text{CH}_2\text{Cl}_2$  (20 mL), and the mixture was allowed to slowly warm to 25 °C under  $\text{N}_2$  as the dry ice sublimed. After 6.5 h, the mixture was quenched with MeOH with ice- $\text{H}_2\text{O}$  cooling and diluted with  $\text{CH}_2\text{Cl}_2$  (50 mL). The mixture was partitioned between sat'd  $\text{NaHCO}_3$  and  $\text{CH}_2\text{Cl}_2$ . Some yellowish precipitate was extracted into  $\text{CH}_2\text{Cl}_2$  by adding some MeOH. The organic fraction was dried ( $\text{Na}_2\text{SO}_4$ ), filtered through celite, and evaporated. The product was flash column chromatographed eluting with  $\text{CHCl}_3$ :2%  $\text{NH}_3$ :2% MeOH to yield ( $\pm$ )-7 (0.426 g, 30%). Part of the free base was converted to the HCl salt with 1.0 M HCl in  $\text{Et}_2\text{O}$ :  $^1\text{H}$  NMR (free base,  $\text{CDCl}_3$ )  $\delta$  1.5-1.8 (br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 1.8-2.9 (complex, 9H, 4  $-\text{CH}_2-$  and 1  $-\text{CH}-$ ), 2.55 (s, 3H,  $-\text{NCH}_3$ ), 5.21 (s, 1H,  $-\text{CH}-$ ), 5.83 (d,  $J$  = 8.6 Hz, 1H,  $-\text{CH}-$ ), 6.22 (s, 1H, aromatic), 6.46 (m, 1H, aromatic), 6.78 (d,  $J$  = 8.1 Hz, 1H, aromatic), 7-7.4 (complex, 10H, aromatic). MS (FAB)  $m/z$  441. Anal. (C, H, N)  $\text{C}_{29}\text{H}_{32}\text{N}_2\text{O}_2\cdot\text{HCl}\cdot\text{H}_2\text{O}$ .

**Example 36****2-(2-Nitro-4,5-dichlorophenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-7-nitro-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-8, ADL-01-0029-7)**

- ADL-01-0029-7 was prepared via the general DCC/pyr coupling method from (±)-2 (0.5790 g, 2.103 mmol), 2-nitro-4,5-dichlorophenylacetic acid (1.0512 g, 4.204 mmol), DCC (0.8948 g, 4.34 mmol), and pyr (0.35 mL, 4.3 mmol). After stirring at 25 °C overnight, more 2-nitro-4,5-dichlorophenylacetic acid (1.0510 g, 4.203 mmol), DCC (0.8946 g, 4.34 mmol), and CH<sub>2</sub>Cl<sub>2</sub> (10 mL) were added, and after 5 h, the reaction was worked up according to the general procedure. The crude product was purified by gravity column eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub> before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and washed with hot MeOH to yield (±)-8·HCl (0.4948 g, 43% yield): m.p. (HCl salt) >250 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.8-2. (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.2-4.6 (complex, 11H, 5 -CH<sub>2</sub>- and 1 -CH-), 2.9 (s, 3H, -NCH<sub>3</sub>), 6.1 (d, J = 10.2 Hz, 1H, -CH-), 7.53 (d, J = 8.5 Hz, 1H, aromatic), 7.89 (s, 1H, aromatic), 7.91 (s, 1H, aromatic), 8.12 (d of d, J = 2.2 Hz and 8.5 Hz, 1H, aromatic), 8.4 (s, 1H, aromatic). MS (FAB) m/z 507. Anal. (C, H, N) C<sub>23</sub>H<sub>24</sub>N<sub>4</sub>O<sub>3</sub>Cl<sub>2</sub>·HCl.

**Example 37****2-(3,4-Dichlorophenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-7-nitro-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-9, ADL-01-0031-3)**

- ADL-01-0031-3 was prepared via the general DCC/pyr coupling procedure from (±)-2 (1.8173 g, 6.600 mmol), 3,4-dichlorophenylacetic acid (2.7066 g, 13.20 mmol), DCC (2.8057 g, 13.60 mmol), and pyr (1.10 mL, 13.6 mmol). The product was purified by flash column eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:1% MeOH before it was converted to the HCl salt with Et<sub>2</sub>O·HCl and washed with hot MeOH to yield (±)-9·HCl (2.49 g, 76%): m.p. (HCl salt) 255-257 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.8-2 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2-4.2 (complex, 11H, 5 -CH<sub>2</sub>- and 1 -CH-), 2.83 (s, 3H, -NCH<sub>3</sub>), 6.1 (d, J = 9.8 Hz, 1H, -CH-), 7.3-7.7 (complex, 5H, aromatic), 8.06 (d of d, J = 2.4 Hz and 8.6 Hz, 1H, aromatic). MS (FAB) m/z 462. Anal. (C, H, N) C<sub>23</sub>H<sub>23</sub>N<sub>3</sub>O<sub>3</sub>Cl<sub>2</sub>·HCl.

**Example 38****2-(3,4-Dichlorophenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-7-amino-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-10, ADL-01-0032-1)**

- With stirring at 55 °C, Raney nickel (50% slurry in H<sub>2</sub>O) was added in small portions to a mixture of (±)-9 (2.10 g, 4.54 mmol) and hydrazine hydrate (4 mL) in EtOH (60 mL) until all hydrazine was decomposed in 30 min. The mixture was filtered through celite, and the Raney nickel was washed with hot MeOH (120 mL). The filtrate was evaporated and dried in vacuo before the residue was partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>, which was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. The product was purified by gravity column eluting with CHCl<sub>3</sub>:2% NH<sub>3</sub>:0.5% MeOH before it was converted to the HCl salt with Et<sub>2</sub>O·HCl to yield (±)-10·HCl (0.3 g, 14%, unoptimized): m.p. (HCl salt) >250 °C; <sup>1</sup>H NMR (free base, CDCl<sub>3</sub>) δ 1.64 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 1.9-3.8 (complex, 11H, 5 -CH<sub>2</sub>- and 1 -CH-), 2.59 (s, 3H, -NCH<sub>3</sub>), 5.8 (d, J = 9.7 Hz, 1H, -CH-), 6.29 (s, 1H, aromatic), 6.43 (d, J = 8 Hz, 1H, aromatic), 6.8 (d, J = 8 Hz, 1H, aromatic), 7.17 (d, J = 8 Hz, 1H, aromatic), 7.3 (m, 2H, aromatic). MS (FAB) m/z 432. Anal. (C, H, N) C<sub>23</sub>H<sub>27</sub>N<sub>3</sub>OCl<sub>2</sub>·2HCl.

**Example 39****2-(4-Methylsulfonylphenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-7-nitro-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-11, ADL-01-0034-7)**

- ADL-01-0034-7 was prepared via the general DCC/pyr coupling procedure from (±)-2 (0.3414 g, 1.240 mmol), 4-methylsulfonylphenylacetic acid (0.5309 g, 2.478 mmol), DCC (0.5288 g, 2.563 mmol), and pyr (0.21 mL, 2.55 mmol). After stirring at 25 °C overnight, more of 4-methylsulfonylphenylacetic acid (0.5307 g, 2.477 mmol), DCC (1.1356 g, 5.504 mmol), and CH<sub>2</sub>Cl<sub>2</sub> (13 mL) were added, and the mixture was worked up according to the general procedure after another night of stirring. The product was purified by gravity column eluting with CHCl<sub>3</sub>:2% NH<sub>3</sub>:1% MeOH before it was converted to the HCl salt with Et<sub>2</sub>O-HCl and washed with hot MeOH to yield (±)-11·HCl (0.4455 g, 76%): m.p. (HCl salt) 284-285 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.96 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.1-4.3 (complex, 11H, 5 -CH<sub>2</sub>- and 1 -CH-), 2.88 (s, 3H, -NCH<sub>3</sub>), 3.24 (s, 3H, -SO<sub>2</sub>CH<sub>3</sub>), 6.13 (d, J = 10 Hz, 1H, -CH-), 7.51 (d, J = 8.8 Hz, 1H, aromatic), 7.68 (m, 3H, aromatic), 7.9 (d, J = 8.7 Hz, 2H, aromatic), 8.08 (d of d, J = 2.6 Hz and 8.5 Hz, 1H, aromatic). MS (FAB) m/z 472. Anal. (C, H, N) C<sub>24</sub>H<sub>29</sub>N<sub>3</sub>O<sub>3</sub>S·HCl·0.25CH<sub>2</sub>Cl<sub>2</sub>.

**Example 40**

- 2-(3,4-Dichlorophenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-7-[N,N-bis-(t-butoxycarbonylmethyl)-amino]-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-12, ADL-01-0037-0)**

- With stirring in ice-H<sub>2</sub>O under N<sub>2</sub>, t-butyl bromoacetate (0.34 mL, 2.32 mmol) was added dropwise to a mixture of (±)-10 (0.4014 g, 0.928 mmol) and NEt(iPr)<sub>2</sub> (0.81 mL, 4.64 mmol) in dry THF (10 mL). After 10 min, the mixture was stirred at 25 °C under N<sub>2</sub> overnight before more t-butyl bromoacetate (0.30 mL) was added at 25 °C. After stirring overnight, more NEt(iPr)<sub>2</sub> (0.40 mL) and t-butyl bromoacetate (0.30 mL) were added, and after one more night of stirring, the mixture was partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>. The aqueous fraction was extracted with more CH<sub>2</sub>Cl<sub>2</sub>, and the combined organic fraction was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. The crude product was purified by gravity column eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:1% MeOH before part of the free base was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O with stirring in ice-H<sub>2</sub>O. The residue was sonicated in hexane to yield (±)-12·2HCl (0.1610 g, 25%, unoptimized): m.p. (HCl salt) 143 °C (dec); <sup>1</sup>H NMR (free base, CDCl<sub>3</sub>) δ 1.39 (s, 9H, t-butyl), 1.43 (s, 9H, t-butyl), 1.65 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 1.9-4.1 (complex, 15H, 7 -CH<sub>2</sub>- and 1 -CH-), 2.58 (s, 3H, -NCH<sub>3</sub>), 5.8 (m, 1H, -CH-), 6.2-7.4 (complex, 6H, aromatic). MS (FAB) 660. Anal. (C, H, N) C<sub>33</sub>H<sub>47</sub>N<sub>3</sub>O<sub>5</sub>Cl<sub>2</sub>·2HCl·0.5CH<sub>3</sub>CN.

**Example 41****2-(3,4-Dichlorophenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-7-[N,N-bis-(carboxymethyl)amino]-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-13, ADL-01-0044-6)**

- A solution of (±)-12 (0.35 g, 0.5 mmol) in 1:1 AcOH and 3 N HCl (8 mL) with some anisole (2 drops) was stirred at 25 °C overnight before conc. HCl (0.5 mL) was added, and the mixture was warmed to 40 °C for 1 h. Then some anisole (4 drops) was added, and the mixture was stirred at 25 °C for 5 h before it was evaporated. The residue was sequentially

- evaporated from iPrOH and PhCH<sub>3</sub> before it was sonicated with Et<sub>2</sub>O to yield (±)-13·HCl (0.2360 g, 81%): m.p. (HCl salt) 160 °C (dec); <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.93 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.2-4.3 (complex, 15H, 7 -CH<sub>2</sub>- and 1 -CH-), 2.79 (s, 3H, -NCH<sub>3</sub>-), 5.93 (d, J = 10.7 Hz, 1H, -CH-), 6.37 (s, 1H, aromatic), 6.68 (d, J = 8.8 Hz, 1H, aromatic), 7.00 (d, J = 8.1 Hz, 1H, aromatic), 7.40 (d, J = 8.1 Hz, 1H, aromatic), 7.63 (m, 2H, aromatic). MS (FAB) m/z 490 (M+1-CH<sub>2</sub>CO<sub>2</sub>H). Anal. (C, H, N) C<sub>27</sub>H<sub>31</sub>N<sub>3</sub>O<sub>5</sub>Cl<sub>2</sub>·1HCl.

**Example 42**

- 10 **2-(3,4-Dichlorophenyl)-N-methyl-N-[(±)-trans-2-[1-pyrrolidinyl]-7-[N,N-bis-(ethoxycarbonylmethyl)-amino]-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-14, ADL-01-0052-9)**

- 15 With stirring in ice-H<sub>2</sub>O under N<sub>2</sub>, ethyl bromoacetate (0.47 mL, 4.21 mmol) was added dropwise to a mixture of (±)-10 (0.3640 g, 0.842 mmol) and NEt(iPr)<sub>2</sub> (0.88 mL, 5.05 mmol) in dry THF (6 mL). After 10 min, the mixture was stirred at 25 °C under N<sub>2</sub> overnight before it was partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>. The aqueous fraction was extracted with more CH<sub>2</sub>Cl<sub>2</sub>, and the combined organic fraction was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. The product was purified by gravity column eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:1% MeOH before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and washed with Et<sub>2</sub>O to yield (±)-14·HCl (0.27 g, 47%): m.p. (HCl salt) 128 °C (dec); <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.2 (m, 6H, 2 -CH<sub>3</sub>), 1.9 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.2-4.4 (complex, 19H, 9 -CH<sub>2</sub>- and 1 -CH-), 2.78 (s, 3H, -NCH<sub>3</sub>), 5.9 (d, J = 10.3 Hz, 1H, -CH-), 6.14 (s, 1H, aromatic), 6.49 (d, J = 8.2 Hz, 1H, aromatic), 6.91 (d, J = 8.3 Hz, 1H, aromatic), 7.39 (d, J = 8.3 Hz, 1H, aromatic), 7.6 (m, 2H, aromatic). MS (FAB) m/z 605. Anal. (C, H, N) C<sub>31</sub>H<sub>39</sub>N<sub>3</sub>O<sub>5</sub>Cl<sub>2</sub>·1.25HCl·0.3CH<sub>3</sub>CN.

**Example 43**

- 30 **2-(3,4-Dichlorophenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-7-(N-diethylphosphoramidato-amino)-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-15, ADL-01-0053-7)**

- 35 With stirring in ice-H<sub>2</sub>O under N<sub>2</sub>, diethyl chlorophosphate (0.57 mL, 3.92 mmol) was added dropwise to a mixture of (±)-10 (0.3393 g, 0.785 mmol) and NEt(iPr)<sub>2</sub> (0.82 mL, 4.71 mmol) in dry THF (6 mL). After 10 min, the mixture was stirred at 25 °C under N<sub>2</sub> overnight before the mixture was evaporated and dried in vacuo. The residue was partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>. The aqueous fraction was extracted with more CH<sub>2</sub>Cl<sub>2</sub>, and the combined organic fraction was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. The product was purified by gravity column eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:1.5% MeOH before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and sonicated in Et<sub>2</sub>O to yield (±)-15·HCl (0.4205 g, 89%): m.p. (HCl salt) 247-249 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.2 (m, 6H, 2 -CH<sub>3</sub>), 1.95 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.2-4.1 (complex, 15H, 7 -CH<sub>2</sub>- and 1 -CH-), 2.75 (s, 3H, -NCH<sub>3</sub>), 5.98 (d, J = 10.3 Hz, 1H, -CH-), 6.7 (s, 1H, aromatic), 6.9 (m, 1H, aromatic), 7.03 (d, J = 8.4 Hz, 1H, aromatic), 7.3 (d of d, J = 2 Hz and 8.2 Hz, 1H, aromatic), 7.6 (m, 2H, aromatic), 7.92 (d, J = 9.7 Hz, -NHP). MS (FAB) m/z 568. Anal. (C, H, N) C<sub>27</sub>H<sub>36</sub>N<sub>3</sub>O<sub>4</sub>PCl<sub>2</sub>·HCl·0.25H<sub>2</sub>O.

**Example 44****2-(3,4-Dichlorophenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-7-[N-2-(diethylphosphoryl)ethyl-amino]-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-16, ADL-01-0070-1)**

5 With stirring in ice-H<sub>2</sub>O under N<sub>2</sub>, diethyl 2-bromoethylphosphonate (0.8601 g, 3.52 mmol) was added to a mixture of (±)-10 (0.3042 g, 0.704 mmol) and NEt(iPr)<sub>2</sub> (0.74 mL, 4.2 mmol) in dry THF (4 mL). After 10 min, the mixture was stirred at 25 °C under N<sub>2</sub> for 2.5 days before more diethyl 2-bromoethylphosphonate (0.8546 g) and NEt(iPr)<sub>2</sub> (0.74 mL, 4.2 mmol) were added. After stirring for 14 more days, the mixture was evaporated to dryness and dried in vacuo before the residue was partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>. The aqueous fraction was extracted with more CH<sub>2</sub>Cl<sub>2</sub>, and the combined organic fraction was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. The product was purified by gravity column eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:1% MeOH and then by radial chromatography eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>. The product was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and solidified by evaporation from CH<sub>2</sub>Cl<sub>2</sub> and sonication with Et<sub>2</sub>O to yield (±)-16HCl (0.2466 g, 52%): m.p. (HCl salt) 151 °C (dec); <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.24 (t, J = 7 Hz, 6H, 2 -CH<sub>3</sub>), 1.93 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2-4.3 (complex, 19H, 9 -CH<sub>2</sub>- and 1 -CH-), 2.8 (s, 3H, -NCH<sub>3</sub>), 5.96 (d, J = 10.2 Hz, 1H, -CH-), 6.69 (br s, 1H, aromatic), 6.87 (d, J = 7.5 Hz, 1H, aromatic), 7.11 (d, J = 8.1 Hz, 1H, aromatic), 7.43 (d, J = 8.3 Hz, 1H, aromatic), 7.64 (m, 2H, aromatic). MS (FAB) m/z 596. Anal. (C, H, N) C<sub>29</sub>H<sub>40</sub>N<sub>3</sub>O<sub>4</sub>PCl<sub>2</sub>·2HCl.

**Example 45****2-(3,4-Dichlorophenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-6-methoxy-7-(N-benzyl-N-methylaminosulfonyl)-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-19, ADL-01-0090-9).**

ADL-01-0090-9 was prepared via the general DCC/pyr coupling procedure from (±)-17 (0.6213 g, 1.40 mmol), 3,4-dichlorophenylacetic acid (0.5764 g, 2.81 mmol), DCC (0.5951 g, 2.88 mmol), and pyr (0.23 mL, 2.88 mmol). The product was gravity column chromatographed eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:1% MeOH and further purified by radial chromatography eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>. The product was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O to yield (±)-19HCl (0.3 g, 32%): m.p. (HCl salt) 150 °C (dec); <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.91 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.2-4.1 (complex, 11H, 5 -CH<sub>2</sub>- and 1 -CH-), 2.55 (s, 3H, -NCH<sub>3</sub>), 2.77 (s, 3H, -NCH<sub>3</sub>), 3.88 (s, 3H, -OCH<sub>3</sub>), 4.2 (s, 2H, -CH<sub>2</sub>Ph), 6.0 (d, J = 9.7 Hz, 1H, -CH-), 7.10 (s, 1H, aromatic), 7.2-7.4 (complex, 7H, aromatic), 7.55 (m, 2H, aromatic). MS (FAB) m/z 630. Anal. (C, H, N) C<sub>31</sub>H<sub>37</sub>N<sub>3</sub>O<sub>4</sub>Cl<sub>2</sub>·SHCl·0.5H<sub>2</sub>O.

**Example 46****2-(3,4-Dichlorophenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-7-(N-benzyl-N-methylaminosulfonyl)-1,2,3,4-tetrahydronaphth-1-yl]acetamide ((±)-20, ADL-01-0099-0)**

ADL-01-0099-0 was prepared via the general DCC/pyr coupling procedure from (±)-18 (0.4530 g, 1.095 mmol), 3,4-dichlorophenylacetic acid (0.4485 g, 2.19 mmol), DCC (0.4677 g, 2.27 mmol), and pyr (0.18 mL, 2.26 mmol). The product was purified by flash column eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>, and then by radial chromatography eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>. The product was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and then washed

with hot MeOH to yield ( $\pm$ )-20 HCl (0.33 g, 47%): m.p. (HCl salt) 251-254 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>)  $\delta$  1.97 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.3-4.2 (complex, 13H, 6 -CH<sub>2</sub>- and 1 -CH-); 2.49 (s, 3H, -NCH<sub>3</sub>), 2.90 (s, 3H, -NCH<sub>3</sub>), 6.17 (d, J = 10.4 Hz, 1H, -CH-), 7.2-7.8 (complex, 11H, aromatic). MS (FAB) m/z 600. Anal. (C, H, N) C<sub>31</sub>H<sub>35</sub>N<sub>3</sub>SO<sub>3</sub>Cl<sub>2</sub>·HCl.

5

**Example 47****2-(2-Nitro-4,5-dichlorophenyl)-N-methyl-N-[( $\pm$ )-trans-2-(1-pyrrolidinyl)-indan-1-yl]acetamide (( $\pm$ )-24, ADL-01-0104-8)**

- 10 ADL-01-0104-8 was prepared via the general DCC/pyr coupling procedure from ( $\pm$ )-23 (0.4265 g, 1.971 mmol), 2-nitro-4,5-dichlorophenylacetic acid (0.9859 g, 3.943 mmol), DCC (0.8350 g, 4.047 mmol), and pyr (0.33 mL, 4.06 mmol). The crude product was purified by silica gel column eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub> before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and crystallized from MeOH to yield ( $\pm$ )-24 HCl (0.3630 g, 38%, first
- 15 crop): m.p. (HCl salt) 284-287 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>)  $\delta$  1.8-2.1 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.84 (s, 3H, -NCH<sub>3</sub>), 3-4.4 (complex, 9H, 4 -CH<sub>2</sub>- and 1 -CH-), 6.37 (d, J = 8. Hz, 1H, -CH-), 7.08 (br s, 1H, aromatic), 7.3 (m, 3H, aromatic), 7.92 (s, 1H, aromatic), 8.41 (s, 1H, aromatic). MS (FAB) m/z 448. Anal. (C, H, N) C<sub>22</sub>H<sub>23</sub>N<sub>3</sub>O<sub>3</sub>Cl<sub>2</sub>·HCl.

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**Example 48****2-(2-Nitro-4-trifluoromethylphenyl)-N-methyl-N-[( $\pm$ )-trans-2-(1-pyrrolidinyl)-indan-1-yl]acetamide (( $\pm$ )-26, ADL-01-0106-3)**

- ADL-01-0106-3 was prepared via the general DCC/pyr coupling procedure from ( $\pm$ )-23
- 25 (0.3229 g, 1.492 mmol), 2-nitro-4-trifluoromethylphenylacetic acid (0.5579 g, 2.24 mmol), DCC (0.5512 g, 2.67 mmol), and pyr (0.19 mL, 2.31 mmol). The crude product was gravity column chromatographed eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub> before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and crystallized from MeOH-Et<sub>2</sub>O to yield ( $\pm$ )-26 HCl (0.3643 g, 50%): m.p. (HCl salt) 249-250 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>)  $\delta$  1.8-2.1 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.89 (s, 3H, -NCH<sub>3</sub>), 3-4.6 (complex, 9H, 4 -CH<sub>2</sub>- and 1 -CH-), 6.40 (d, J = 8.1 Hz, 1H, -CH-), 7.1 (br s, 1H, aromatic), 7.3 (m, 3H, aromatic), 7.83 (d, J = 8.1 Hz, 1H, aromatic), 8.17 (d, J = 7.8 Hz, 1H, aromatic), 8.41 (s, 1H, aromatic). MS (FAB) m/z 448. Anal. (C, H, N) C<sub>23</sub>H<sub>24</sub>N<sub>3</sub>O<sub>3</sub>F<sub>3</sub>·HCl.
- 30

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**Example 49****2,2-Diphenyl-N-methyl-N-[( $\pm$ )-trans-2-(1-pyrrolidinyl)-indan-1-yl]acetamide (( $\pm$ )-28, ADL-01-0108-9)**

- ADL-01-108-9 was prepared via the general DCC/pyr coupling procedure from ( $\pm$ )-23
- 40 (0.2615 g, 1.209 mmol), diphenylacetic acid (0.5123 g, 2.41 mmol), DCC (0.5138 g, 2.49 mmol), and pyr (0.20 mL, 2.5 mmol). The crude product was purified by gravity column eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub> before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and crystallized from MeOH to yield ( $\pm$ )-28 HCl (0.3815 g, 71%): m.p. (HCl salt) >300 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>; the cis-trans rotamers are observed in about 3.6 to 1 ratio.
- 45 Only peaks for the major rotamer are reported.)  $\delta$  1.88 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.75 (s, 3H, -NCH<sub>3</sub>), 3-4.2 (complex, 7H, 3 -CH<sub>2</sub>- and 1 -CH-), 5.61 (s, 1H, -CH-), 6.5 (d, J = 8 Hz, 1H, -

CH-), 6.88 (d,  $J = 6.5$  Hz, 1H, aromatic), 7.1-7.4 (complex, 13 H, aromatic). MS (FAB)  $m/z$  411. Anal. (C, H, N)  $C_{28}H_{30}N_2O \cdot HCl \cdot 0.75 H_2O$ .

### Example 50

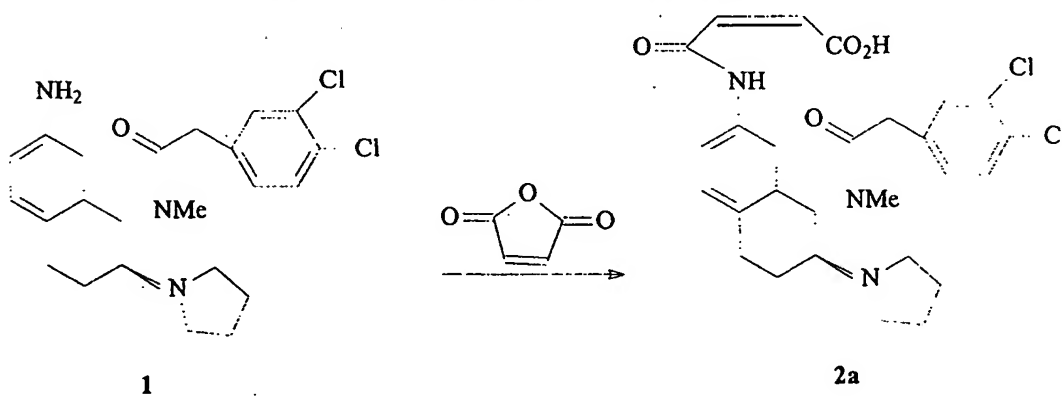
#### 5 2-(4-Methylsulfonylphenyl)-N-methyl-N-[(±)-trans-2-(1-pyrrolidinyl)-indan-1-yl]acetamide ((±)-29, ADL-01-0109-7)

ADL-01-0109-7 was prepared via the general DCC/pyr coupling procedure from (±)-23 (0.3271 g, 1.51 mmol), 4-methylsulfonylphenylacetic acid (0.6464 g, 3.017 mmol), DCC (0.6438, 3.12 mmol), and pyr (0.25 mL, 3.1 mmol). The product was purified by gravity column eluting with  $CH_2Cl_2$ :2%  $NH_3$  before it was converted to the HCl salt with 1.0 M HCl in  $Et_2O$  and crystallized from MeOH- $Et_2O$  to yield (±)-29·HCl (0.5295 g, 78%); m.p. (HCl salt) 246-248 °C;  $^1H$  NMR (HCl salt, DMSO- $d_6$ )  $\delta$  1.8-2 (br s, 4H,  $-CH_2Cl_2-$ ), 2.81 (s, 3H,  $-NCH_3$ ), 2.9-4.2 (complex, 9H, 4- $-CH_2-$  and 1- $-CH-$ ), 3.21 (s, 3H,  $-SO_2CH_3$ ), 6.4 (d,  $J = 8.1$  Hz, 1H, aromatic), 7 (m, 1H, aromatic), 7.3 (m, 3H, aromatic), 7.58 (d,  $J = 8.1$  Hz, 2H, aromatic), 7.9 (d,  $J = 7.8$  Hz, 2H, aromatic). MS (FAB)  $m/z$  413. Anal. (C, H, N)  $C_{23}H_{28}N_2SO_3 \cdot HCl \cdot 0.25H_2O$ .

The preparation of a compound of Formula IIA is shown in Example 2a.

### EXAMPLE 2a

#### 20 (Z)-(±)-trans-[(7-Amino-2-(3,4-dichlorophenyl)-N-methyl-2-(1-pyrrolidinyl)-1,2,3,4-tetrahydronaphth-1-yl)acetamido]4-oxo-butenoic acid



To a solution of 7-amino compound (1)<sup>1</sup> (0.266 g, 0.614 mmol) in anhydrous THF (4.5 mL) under a nitrogen atmosphere was added a solution of maleic anhydride (0.0602 g, 0.614 mmol) in anhydrous TH (0.53 mL). The reaction mixture was stirred at room temperature for 20 h and the resulting solid was filtered, washed with THF and ether, and dried in vacuo. The solid was then suspended in hot water, filtered, and dried to give 2, 0.267 g (82%); mp 221-223°C; MS (FAB) 530 ( $M+1$ );  $^1H$  NMR (200 MHz, DMSO- $d_6$ )  $\delta$  1.50-1.93 (m, 2H), 2.00-3.10 (m, 9H), 2.66 (s, 3H), 3.83 (m, 2H), 5.80 (m, 1H), 6.22 (m, 2H), 7.10 (d,  $J = 7.5$  Hz,

1H), 7.26 (s, 1H), 7.35 (d, J=8.0 Hz, 1H), 7.48 (d, J=8.5 Hz, 1H), 7.55-7.65 (m, 2H). Anal. (C, H, N)  $C_{27}H_{29}N_3O_4Cl_2 \cdot 0.5H_2O$ .

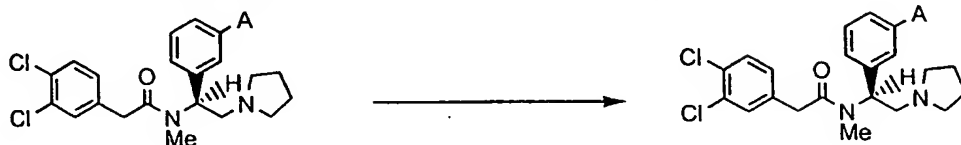
Ref.

1. U.S. Patent 5,744,458

5

### Compounds of formula III

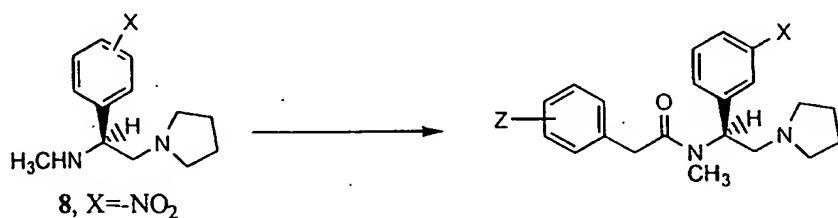
Compounds having the following structures were prepared.



- 1, ADL-01-0007-3, A= $-NH_2$
- 2, ADL-03-1066, A=(R)- $NHC(O)CH_2CH_2CH(NH_2)(CO_2H)$
- 3, ADL-01-0006-5, A=(S)- $NHC(O)CH_2CH(NH_2)(CO_2H)$
- 4, ADL-01-0008-1, A=(R)- $NHC(O)CH(NH_2)(CH_2CO_2H)$
- 5, ADL-01-0009-9, A=(S)- $NHC(O)CH(NH_2)(CH_2CO_2H)$
- 6, ADL-01-0010-7, A=(S,S)- $NHC(O)CH(CH_2CO_2H)NHC(O)CH(CH_2CO_2H)(NH_2)$
- 7, ADL-01-0011-5, A= $-N(SO_2Me)_2$

10

Compounds 1-5 were prepared by the method described in Chang, A.-C., Ph.D. Thesis, University of Minnesota-Twin Cities, 1995.

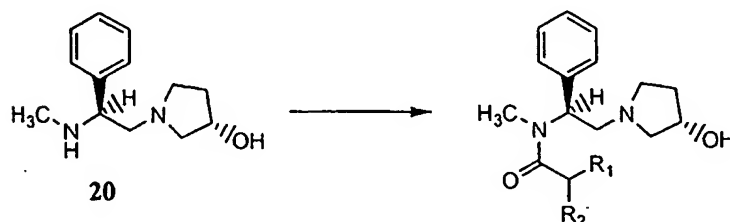


- 9, ADL-01-0113-9, X= $-NH_2$ , Z=2- $NH_2$
- 10, ADL-01-0115-4, X= $-NO_2$ , Z=2- $-NO_2$
- 11, ADL-01-0124-6, X= $-NHPQEt_2$ , Z=2- $NHPO_3Et_2$
- 12, ADL-01-0126-1, X= $-N(SO_2Me)_2$ , Z=2- $N(SO_2Me)_2$
- 13, ADL-01-0128-7, X= $-NO_2$ , Z=2- $-NO_2$ -4,5- $-Cl_2$
- 14, ADL-01-0129-5, X= $-NO_2$ , Z=4-methylsulfonyl
- 15, ADL-01-0132-9, X= $-NO_2$ , Z=4- $NH_2$
- 16, ADL-01-0133-7, X= $-NO_2$ , Z=4- $N(SO_2Me)_2$
- 17, ADL-01-0136-0, X= $-NH_2$ , Z=4- $N(SO_2Me)_2$
- 18, ADL-01-0138-6, X= $-NO_2$ , Z=4-NHBoc
- 19, ADL-01-0139-4, X= $-NHPQEt_2$ , Z=4- $N(SO_2Me)_2$



Compounds 9-19 were prepared from the appropriate arylacetic acids via DCC/pyr coupling, followed by reduction, deprotection, and/or derivatization via known chemistry. Intermediate 8 was prepared via the method described in Chang, A.-C., Ph.D. Thesis, University of Minnesota-Twin Cities, 1995.

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- 21, ADL-01-0055-2, R<sub>1</sub>=H, R<sub>2</sub>=2-nitrophenyl  
 22, ADL-01-0056-0, R<sub>1</sub>=H, R<sub>2</sub>=2-NO<sub>2</sub>-4,5-Cl<sub>2</sub>-phenyl  
 23, ADL-01-0059-0 (EMD 60400), R<sub>1</sub>=H, R<sub>2</sub>=2-NH<sub>2</sub>-phenyl  
 24, ADL-01-0063-6 (EMD 61753), R<sub>1</sub>=R<sub>2</sub>=phenyl  
 25, ADL-01-0064-4, R<sub>1</sub>=H, R<sub>2</sub>=4-methylsulfonylphenyl  
 26, ADL-01-0067-7, R<sub>1</sub>=H, R<sub>2</sub>=2-NO<sub>2</sub>-4-CF<sub>3</sub>-phenyl  
 27, ADL-01-0076-8, R<sub>1</sub>=H, R<sub>2</sub>=2-NH<sub>2</sub>-4-CF<sub>3</sub>-phenyl

Intermediate 20 was prepared via minor modifications of known methods.<sup>7,8</sup> Compounds 23

- 10 (EMD60400) and 24 (EMD61753) are known compounds that were synthesized in-house via minor modifications of reported methods.<sup>9</sup> Compounds 21, 22 and 25-27 were prepared by DCC coupling, following by reduction where applicable.

Ref.

- (7) Costello, G. F. et al. J. Med. Chem. 1991, 34, 181-189.  
 15 (8) Naylor, A. et al. J. Med. Chem. 1994, 37, 2138-2144.  
 (9) Gottschlich, R. et al. Bioorg. Med. Chem. Letters 1994, 4, 677-682.

### Example 51

- 20 2-(3,4-Dichlorophenyl)-N-methyl-N-([1S]-1-[N-(S-aspartic acid-a-amide-S-aspartic acid-a-amido)-3-aminophenyl]-2-[1-pyrrolidinyl]ethyl)acetamide (6, ADL-01-0010-7)

- With stirring in ice-H<sub>2</sub>O under N<sub>2</sub>, 1,3-dicyclohexylcarbodiimide (DCC, 0.353 g, 1.711 mmol) and dry CH<sub>2</sub>Cl<sub>2</sub> (2 mL) were added to a mixture of 5-t-butyl ester (0.311 g, 0.538 mmol), N-Boc-L-aspartic acid-b-t-butyl ester (0.495 g, 1.711 mmol), and 1-hydroxybenzotriazole (HOBT, 0.232 g, 1.717 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (8 mL). After 5 min, the mixture was stirred at 25 °C under N<sub>2</sub> overnight before H<sub>2</sub>O (1-mL) was added, and the mixture was filtered through celite. The 1,3-dicyclohexylurea (DCU) was washed with CH<sub>2</sub>Cl<sub>2</sub> (18 mL). The filtrate was partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>, which was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. After flash column chromatography eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:2% MeOH, the protected intermediate (0.411 g, 90%) was dissolved in 3N HCl (4 mL), AcOH (4 mL) with anisole (2 drops), and stirred at 25 °C

overnight. The mixture was then evaporated to dryness, and evaporation from iPrOH then yielded ADL-01-0010-7: <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 2.0 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9 (s, 3H, -NCH<sub>3</sub>), 6.1 (br m, 1H, -CH-). MS (FAB) m/z 636. Anal. (C, H, N) C<sub>23</sub>H<sub>35</sub>N<sub>5</sub>O<sub>7</sub>Cl<sub>2</sub>·1.5 HCl·0.25iPrOH.

5

#### Example 52

##### 2-(3,4-Dichlorophenyl)-N-methyl-N-[(1S)-1-[N-(bis-methylsulfonamido)-3-aminophenyl]-2-(1-pyrrolidinyl)ethyl]acetamide (7, ADL-01-0011-5)

10

With stirring at 25 °C, a solution of methanesulfonyl chloride (MsCl, 0.25 mL, 3.2 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (0.75 mL) was added to a mixture of ADL-01-0007-3 (0.225 g, 0.554 mmol) and Et<sub>3</sub>N (1 mL, 7 mmol) in dry CH<sub>2</sub>Cl<sub>2</sub> (4 mL), and the mixture was stirred at 25 °C fitted with a drying tube. After 5 h, more CH<sub>2</sub>Cl<sub>2</sub> (6 mL), MsCl (0.5 mL), and Et<sub>3</sub>N (2 mL) were added, and the mixture was stirred at 25 °C overnight before it was partitioned between CH<sub>2</sub>Cl<sub>2</sub> (50 mL) and sat'd NaHCO<sub>3</sub>. The aqueous fraction was extracted with more CH<sub>2</sub>Cl<sub>2</sub> (25 mL), and the combined organic fraction was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. Acetonitrile was used to azeotrope off Et<sub>3</sub>N before the product was gravity column chromatographed twice eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:2% MeOH. The pure product was then treated with 1.0 M HCl in Et<sub>2</sub>O to yield 7HCl (0.131 g, 39%, unoptimized): m.p. (HCl salt) 145 °C (dec); <sup>1</sup>H NMR (free base, CDCl<sub>3</sub>) δ 1.7 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.4-3.8 (complex, 8H, 4 -CH<sub>2</sub>-), 2.7 (s, 3H, -NCH<sub>3</sub>), 3.37 (s, 6H, 2 -SO<sub>2</sub>CH<sub>3</sub>), 6.1 (m, 1H, -CH-), 7.1-7.4 (complex, 7H, aromatic). MS (FAB) m/z 562. Anal. (C, H, N) C<sub>23</sub>H<sub>29</sub>N<sub>5</sub>O<sub>5</sub>S<sub>2</sub>Cl<sub>2</sub>·HCl·0.75H<sub>2</sub>O.

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#### Example 53

##### 2-(2-Nitrophenyl)-N-methyl-N-[(1S)-1-(3-nitrophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (10, ADL-01-0115-4)

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ADL-01-0115-4 was prepared via the general DCC/pyr coupling procedure from 8 (1.4886 g, 5.97 mmol), 2-nitrophenylacetic acid (2.1619 g, 11.93 mmol), DCC (2.5402 g, 12.31 mmol), and pyridine (1.00 mL, 12.36 mmol). The crude product was converted to the HCl salt with Et<sub>2</sub>O·HCl without chromatography and crystallized from MeOH-Et<sub>2</sub>O. The first crop was recrystallized again from MeOH-Et<sub>2</sub>O to yield 10HCl (1.3663 g, 51%): m.p. (HCl salt) 258-259 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.97 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.91 (s, 3H, -NCH<sub>3</sub>), 3.11-4.45 (complex, 8H, 4 -CH<sub>2</sub>-), 6.17 (m, 1H, -CH-), 7.51-8.25 (complex, 8H, aromatic). MS (FAB) m/z 413. Anal. (C, H, N) C<sub>21</sub>H<sub>24</sub>N<sub>4</sub>O<sub>5</sub>·HCl·0.25H<sub>2</sub>O.

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#### Example 54

##### 2-(2-Aminophenyl)-N-methyl-N-[(1S)-1-(3-aminophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (9, ADL-01-0113-9)

40

With stirring at 55 °C, Raney nickel was added in small quantities to a mixture of 10 (0.9857 g, 2.3899 mmol) and hydrazine hydrate (55%, 2 mL) in EtOH (30 mL) until gas evolution stopped in about 10 min. The mixture was then filtered through celite, and the Raney nickel was washed with hot MeOH (100 mL). The filtrate was evaporated and dried in vacuo before the residue was partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>, which was dried (Na<sub>2</sub>SO<sub>4</sub>),

45

filtered through celite, and evaporated. The product was gravity column chromatographed eluting with  $\text{CHCl}_3$ :2%  $\text{NH}_3$ :2% MeOH before it was converted to the HCl salt with  $\text{Et}_2\text{O}$ -HCl to yield 9·3HCl (0.3159 g, 29%, unoptimized): m.p. (HCl salt) 219-222 °C;  $^1\text{H}$  NMR (HCl salt,  $\text{DMSO}-d_6$ )  $\delta$  1.98 (br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 2.87 (s, 3H,  $-\text{NCH}_3$ ), 3.2-4.3 (complex, 8H, 4- $-\text{CH}_2-$ ), 6.1 (m, 1H,  $-\text{CH}-$ ), 7.11-7.45 (complex, 8H, aromatic). MS (FAB)  $m/z$  353. Anal. (C, H, N)  $\text{C}_{21}\text{H}_{28}\text{N}_4\text{O}_3\text{HCl} \cdot 0.25\text{H}_2\text{O}$ .

10

**Example 55**

**2-(N-Diethyl phosphoramidate-2-aminophenyl)-N-methyl-N-[(1S)-1-(N-diethyl phosphoramidate-3-aminophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (11, ADL-01-0124-6)**

15 With stirring in ice- $\text{H}_2\text{O}$  under  $\text{N}_2$ , diethyl chlorophosphate (0.53 mL, 3.67 mmol) was added to a mixture of 9 (0.2394 g, 0.6792 mmol) and  $\text{NEt}(\text{iPr})_2$  (0.77 mL, 4.40 mmol) in dry THF (5 mL). After 10 min, the mixture was stirred at 25 °C under  $\text{N}_2$  for 3.5 days before it was diluted with  $\text{CH}_2\text{Cl}_2$ , evaporated, and dried in vacuo. The residue was partitioned between sat'd  $\text{NaHCO}_3$  and  $\text{CH}_2\text{Cl}_2$ . The aqueous fraction was extracted with more  $\text{CH}_2\text{Cl}_2$ , and the combined organic fraction was dried ( $\text{Na}_2\text{SO}_4$ ), filtered through celite, and evaporated. The product was chromatographed eluting with  $\text{CH}_2\text{Cl}_2$ : 2%  $\text{NH}_3$ : 2% MeOH before it was converted to the HCl salt with 1.0 M HCl in  $\text{Et}_2\text{O}$  and crystallized from  $\text{iPrOH}-\text{Et}_2\text{O}$  to yield 11·HCl (0.2364 g, 53%): m.p. (HCl salt) 184-186 °C;  $^1\text{H}$  NMR (HCl salt,  $\text{DMSO}-d_6$ )  $\delta$  1.2 (m, 12H, 4- $-\text{CH}_3$ ), 1.96 (br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 2.81 (s, 3H,  $-\text{NCH}_3$ ), 3-4 (complex, 16H, 8- $-\text{CH}_2-$ ), 6.05 (m, 1H,  $-\text{CH}-$ ), 6.7-7.3 (complex, 9H, aromatic and 1 NH), 8.08 (d,  $J = 9.4$  Hz, 1H, NHP). MS (FAB)  $m/z$  625. Anal. (C, H, N)  $\text{C}_{29}\text{H}_{46}\text{N}_4\text{O}_7\text{P}_2\text{HCl}$ .

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**Example 56**

**2-(N-Bis-sulfonamido-2-aminophenyl)-N-methyl-N-[(1S)-1-(N-bis-sulfonamido-3-aminophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (12, ADL-01-0126-1)**

35 With stirring at 0 °C under  $\text{N}_2$ ,  $\text{MsCl}$  (0.61 mL, 7.87 mmol) was added to a mixture of 9 (0.2774 g, 0.787 mmol) and  $\text{Et}_3\text{N}$  (2.2 mL, 15.7 mmol) in  $\text{CH}_2\text{Cl}_2$  (8 mL). After 10-15 min, the mixture was stirred at 25 °C under  $\text{N}_2$  overnight before the mixture was partitioned between sat'd  $\text{NaHCO}_3$  and  $\text{CH}_2\text{Cl}_2$ . The aqueous fraction was extracted with more  $\text{CH}_2\text{Cl}_2$ , and the combined organic fraction was dried ( $\text{Na}_2\text{SO}_4$ ), filtered through celite, and evaporated. Acetonitrile was added to azeotrope off  $\text{Et}_3\text{N}$ . The product was flash-column chromatographed eluting with  $\text{CH}_2\text{Cl}_2$ : 2%  $\text{NH}_3$  before it was converted to the HCl salt with 1.0 M HCl in  $\text{Et}_2\text{O}$  to yield 12·HCl (0.3564 g, 65%): m.p. (HCl salt) 180 °C;  $^1\text{H}$  NMR (HCl salt,  $\text{DMSO}-d_6$ )  $\delta$  2.0 (br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 2.76 (s, 3H,  $-\text{NCH}_3$ ), 3-4.3 (complex, 8H, 4- $-\text{CH}_2-$ ), 3.53 (s, 12H, 4- $-\text{SO}_2\text{CH}_3$ ), 6.25 (m, 1H,  $-\text{CH}-$ ), 7.3-7.6 (complex, 8H, aromatic). MS (FAB)  $m/z$  665. Anal. (C, H, N)  $\text{C}_{25}\text{H}_{36}\text{N}_4\text{O}_9\text{S}_4\text{HCl} \cdot \text{MeOH}$ .

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**Example 57****2-(2-Nitro-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-(3-nitrophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (13, ADL-01-0128-7)**

- 5 ADL-01-0128-7 was prepared via the general DCC/pyr coupling procedure from 8 (0.3690 g, 1.4801 mmol), 2-nitro-4,5-dichlorophenylacetic acid (0.7301 g, 2.920 mmol), DCC (0.6213 g, 3.01 mmol), and pyridine (0.24 mL, 3.01 mmol). The crude product was converted to the HCl salt with Et<sub>2</sub>O-HCl without chromatography and crystallized from MeOH to yield 13HCl (0.3232 g, 42%): m.p. (HCl salt) 165 °C (dec); <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 2.0 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.93 (s, 3H, -NCH<sub>3</sub>), 3.1-4.3 (complex, 6H, 3 -CH<sub>2</sub>-), 4.4 (s, 2H, benzylic methylene), 6.2 (m, 1H, -CH-), 7.7-7.8 (m, 2H, aromatic), 7.9 (s, 1H, aromatic), 8.14 (s, 1H, aromatic), 8.27 (d, J = 7.7 Hz, 1H, aromatic), 8.43 (s, 1H, aromatic). MS (FAB) m/z 481. Anal. (C, H, N) C<sub>21</sub>H<sub>22</sub>N<sub>4</sub>O<sub>5</sub>Cl<sub>2</sub>·HCl·0.5MeOH.

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**Example 58****2-(4-Methylsulfonylphenyl)-N-methyl-N-[(1S)-1-(3-nitrophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (14, ADL-01-0129-5)**

- 20 ADL-01-0129-5 was prepared via the general DCC/pyr coupling procedure from 8 (0.5138 g, 2.061 mmol), 4-methylsulfonylphenylacetic acid (0.8825 g, 4.119 mmol), DCC (0.8771 g, 4.251 mmol), and pyridine (0.34 mL, 4.245 mmol). The crude product was gravity column chromatographed eluting with CHCl<sub>3</sub>:2% NH<sub>3</sub> before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and crystallized from MeOH to yield 14HCl (0.4695 g, 47%): m.p. (HCl salt) 276-277 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 2.0 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.92 (s, 3H, -NCH<sub>3</sub>), 3.2 (s, 3H, -SO<sub>2</sub>CH<sub>3</sub>), 3.2-4.3 (complex, 8H, 4 -CH<sub>2</sub>-), 6.25 (m, 1H, -CH-), 7.61 (d, J = 7.2 Hz, 2H, aromatic), 7.75 (m, 2H, aromatic), 7.89 (d, J = 7 Hz, 2H, aromatic), 8.12 (s, 1H, aromatic), 8.25 (m, 1H, aromatic). MS (FAB) m/z 446. Anal. (C, H, N) C<sub>22</sub>H<sub>27</sub>N<sub>3</sub>O<sub>5</sub>SHCl.

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**Example 59****2-(N-Butyloxycarbonyl-4-aminophenyl)-N-methyl-N-[(1S)-1-(3-nitrophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (18, ADL-01-0138-6)**

- 35 ADL-01-0138-6 was prepared via the general DCC/pyr coupling method from 8 (1.9948 g, 8.001 mmol), N-Boc-4-aminophenylacetic acid (3.0589 g, 12.173 mmol), DCC (2.6602 g, 12.89 mmol), and pyridine (1.04 mL, 12.9 mmol). The crude product was gravity column chromatographed eluting with CH<sub>2</sub>Cl<sub>2</sub>: 2% NH<sub>3</sub>: 1% MeOH before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and crystallized from MeOH to yield 18HCl (0.4891 g, 12%, first crop): m.p. (HCl salt) 170 °C (dec); <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.49 (s, 9H, t-butyl), 2.01 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.83 (s, 3H, -NCH<sub>3</sub>), 3.1-4.15 (complex, 8H, 4 -CH<sub>2</sub>-), 6.27 (m, 1H, -CH-), 7.17 (d, J = 8 Hz, 2H, aromatic), 7.39 (d, J = 8 Hz, 2H, aromatic), 7.7 (m, 2H, aromatic), 8.09 (s, 1H, aromatic), 8.23 (d, J = 6 Hz, 1H, aromatic), 9.3 (s, 1H, -NHBoc). MS (FAB) 483. Anal. (C, H, N) C<sub>26</sub>H<sub>34</sub>N<sub>4</sub>O<sub>5</sub>·HCl·0.25 H<sub>2</sub>O.

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**Example 60****2-(4-Aminophenyl)-N-methyl-N-[(1S)-1-(3-nitrophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (15, ADL-01-0132-9)**

ADL-01-0138-6 (2.9211 g, 6.053 mmol) and anisole (2 drops) were mixed in AcOH (10 mL) and 4N HCl (10 mL) and stirred at 25 °C overnight, fitted with a drying tube. The mixture was adjusted to pH 13 with 1N NaOH with stirring in ice-H<sub>2</sub>O and then extracted with CH<sub>2</sub>Cl<sub>2</sub> (2 X 70 mL). The combined organic fraction was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. The product was gravity column chromatographed eluting with CHCl<sub>3</sub>:2% NH<sub>3</sub> before it was converted to the HCl salt with Et<sub>3</sub>O-HCl to yield 15HCl (0.5531 g, 22%, unoptimized): m.p. (HCl salt) 200 °C (dec); <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.98 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.86 (s, 3H, -NCH<sub>3</sub>), 3.2-4.3 (complex, 8H, 4 -CH<sub>2</sub>-), 6.25 (m, 1H, -CH-), 7.16 (d, J = 7.4 Hz, 2 H, aromatic), 7.33 (d, J = 7.5 Hz, 2H, aromatic), 7.7 (m, 2H, aromatic), 8.08 (s, 1H, aromatic), 8.23 (m, 1H, aromatic). MS (FAB) m/z 383. Anal. (C, H, N) C<sub>21</sub>H<sub>26</sub>N<sub>4</sub>O<sub>3</sub>·2HCl·0.75H<sub>2</sub>O.

**Example 61****2-(N-Bis-sulfonamido-4-aminophenyl)-N-methyl-N-[(1S)-1-(3-nitrophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (16, ADL-01-0133-7)**

With stirring in ice-H<sub>2</sub>O under N<sub>2</sub>, a solution of MsCl (1.56 mL, 20.17 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (6 mL) was added dropwise over 2-3 min to a mixture of 15 (1.5430 g, 4.0344 mmol) and Et<sub>3</sub>N (5.6 mL, 40 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (24 mL). After 10 min, the mixture was stirred at 25 °C under N<sub>2</sub> overnight before the mixture was partitioned between CH<sub>2</sub>Cl<sub>2</sub> and sat'd NaHCO<sub>3</sub>. The aqueous fraction was extracted with more CH<sub>2</sub>Cl<sub>2</sub>, and the combined organic fraction was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. Acetonitrile was added to azeotrope off Et<sub>3</sub>N before the crude product was flash column chromatographed eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>. The product was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and washed with hot MeOH to yield 16HCl (1.3091 g, 56%, first crop): m.p. (HCl salt) 257-259 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.99 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.87 (s, 3H, -NCH<sub>3</sub>), 3.15-4.3 (complex, 8H, 4 -CH<sub>2</sub>-), 3.51 (s, 6H, 2 -SO<sub>2</sub>CH<sub>3</sub>), 6.25 (m, 1H, -CH-), 7.4 (m, 4H, aromatic), 7.7 (m, 2H, aromatic), 8.1 (s, 1H, aromatic), 8.21 (m, 1H, aromatic). MS (FAB) m/z 539. Anal. (C, H, N) C<sub>33</sub>H<sub>30</sub>N<sub>4</sub>O<sub>7</sub>S<sub>2</sub>·HCl·0.5CH<sub>2</sub>Cl<sub>2</sub>.

**Example 62****2-(N-Bis-sulfonamido-4-aminophenyl)-N-methyl-N-[(1S)-1-(3-aminophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (17, ADL-01-0136-0)**

ADL-01-0136-0 was prepared from 16 (1.0729 g, 1.992 mmol), Raney nickel, and hydrazine hydrate (2 mL) in EtOH (30 mL). The conditions were similar to those used for the preparation of 9. The product was gravity column chromatographed eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>, and the pure fractions were converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O to yield 17HCl (0.1194 g, 11%, unoptimized): m.p. (HCl salt) 252-255 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 2.0 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.86 (s, 3H, -NCH<sub>3</sub>), 3.1-4.2 (complex, 8H, 4 -CH<sub>2</sub>-), 3.54 (s, 6H, 2 -SO<sub>2</sub>CH<sub>3</sub>), 6.1 (m, 1H, -CH-), 6.8-7.5 (complex, 8H, aromatic). MS (FAB) m/z 509. Anal. (C, H, N) C<sub>33</sub>H<sub>32</sub>N<sub>4</sub>O<sub>7</sub>S<sub>2</sub>·1.75HCl.

**Example 63****2-(N-Bis-sulfonamido-4-aminophenyl)-N-methyl-N-[(1S)-1-(N-diethyl phosphoramidate-3-aminophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide (19, ADL-01-0139-4)**

- 5 With stirring in ice-H<sub>2</sub>O under N<sub>2</sub>, diethyl chlorophosphate (0.84 mL, 5.81 mmol) was added to a mixture of 17 (0.7383 g, 1.4514 mmol) and NEt(iPr)<sub>2</sub> (1.5 mL, 8.7 mmol) in dry THF (15 mL). After 10 min, the mixture was stirred at 25 °C under N<sub>2</sub> overnight before more THF (15 mL), NEt(iPr)<sub>2</sub> (0.76 mL), and diethyl chlorophosphate (0.42 mL) were sequentially added.
- 10 After 3 h, the mixture was quenched with H<sub>2</sub>O, diluted with CH<sub>2</sub>Cl<sub>2</sub>, evaporated; and dried in vacuo. The residue was partitioned between CH<sub>2</sub>Cl<sub>2</sub> and sat'd NaHCO<sub>3</sub>. The aqueous fraction was extracted with more CH<sub>2</sub>Cl<sub>2</sub>, and the combined organic fraction was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered through celite, and evaporated. The crude product was flash column chromatographed eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:1.5% MeOH before it was converted to the HCl salt with 1.0 M
- 15 HCl in Et<sub>2</sub>O and crystallized from MeOH to yield 19·HCl (0.3274 g, 33%): m.p. (HCl salt) 245-247 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.193 (t, J = 7 Hz, 6H, 2 -CH<sub>3</sub>), 1.95 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.81 (s, 3H, -NCH<sub>3</sub>), 3.1-4.1 (complex, 12H, 6 -CH<sub>2</sub>-), 3.52 (s, 6H, 2 -SO<sub>2</sub>CH<sub>3</sub>), 6.1 (m, 1H, -CH-), 6.79 (d, J = 7.3 Hz, 1H, aromatic), 6.91 (s, 1H, aromatic), 6.99 (d, J = 7.7 Hz, 1H, aromatic), 7.23 (t, J = 7.8 Hz, 1H, aromatic), 7.36 (d, J = 8.3 Hz, 2H, aromatic), 7.44
- 20 (d, J = 8.6 Hz, 2H, aromatic), 8.09 (d, J = 9.4 Hz, 1H, -NHP). MS (FAB) m/z 645. Anal. (C, H, N) C<sub>27</sub>H<sub>41</sub>N<sub>4</sub>O<sub>8</sub>S<sub>2</sub>·PHCl.

**Example 64**

25 **2-(2-Nitrophenyl)-N-methyl-N-[(1S)-1-phenyl-2-[1-(3S)-(3-hydroxypyrrolidinyl)ethyl]acetamide (21, ADL-01-0055-2)**

- With stirring at 25 °C under N<sub>2</sub>, DCC (0.160 g, 0.79 mmol) was added to a mixture of 2-nitrophenylacetic acid (0.140 g, 0.79 mmol) and pyridine (0.064 mL, 0.79 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL). After 3 min, a solution of 20 (0.160 g, 0.72 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL) was added, followed by NEt(iPr)<sub>2</sub> (0.375 mL, 2.15 mmol). The mixture was stirred at 25 °C under N<sub>2</sub>,
- 30 overnight before sat'd NaHCO<sub>3</sub> was added, and the mixture was filtered through celite. The DCU was washed with a little CH<sub>2</sub>Cl<sub>2</sub>, and the filtrate was partitioned between sat'd NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>, which was dried (MgSO<sub>4</sub>), filtered through celite, and evaporated. Toluene was added to azeotrope off pyridine. The product was flash column chromatographed eluting with CHCl<sub>3</sub>:2% NH<sub>3</sub>:2% MeOH before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O
- 35 and crystallized from MeOH to yield 21·HCl (0.14 g, 47%): m.p. (HCl salt) 226-227 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.8-2.4 (m, 2H, -CH<sub>2</sub>), 2.86 (s, 3H, -NCH<sub>3</sub>), 3-4.5 (complex, 8H, 4 -CH<sub>2</sub>-), 5.5 (m, 1H, -CHOH), 6.1 (m, 1H, -CH-), 7.3-7.8 (complex, 8H, aromatic), 8.11 (d, J = 8 Hz, 1H, aromatic). MS (FAB) m/z 384. Anal. (C, H, N) C<sub>21</sub>H<sub>23</sub>N<sub>3</sub>O<sub>4</sub>·HCl·0.5H<sub>2</sub>O.

**Example 65****2-(2-Nitro-4,5-dichlorophenyl)-N-methyl-N-([1S]-1-phenyl-2-[1-(3S)-(3-hydroxypyrrolidinyl)]ethyl)acetamide (22, ADL-01-0056-0)**

- ADL-01-0056-0 was prepared from 20 (0.2 g, 0.91 mmol), 2-nitro-4,5-dichlorophenylacetic acid (0.45 g, 1.8 mmol), DCC (0.37 g, 1.8 mmol), NEt(iPr)<sub>2</sub> (0.48 mL, 2.7 mmol), and pyridine (0.15 mL, 1.8 mmol). The conditions are similar to those for the preparation of 21. The product was column chromatographed eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:1% MeOH before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and crystallized from iPrOH to yield 22·HCl (0.060 g, 14%): m.p. (HCl salt) 231-233 °C (dec); <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.8-2.4 (m, 2H, -CH<sub>2</sub>-), 2.85 (s, 3H, -NCH<sub>3</sub>), 3.1-4.5 (complex, 8H, 4 -CH<sub>2</sub>-), 5.5 (m, 1H, -CHOH), 6.1 (m, 1H, -CH-), 7.2-7.5 (m, 5H, aromatic), 7.88 (s, 1H, aromatic), 8.42 (s, 1H, aromatic). MS (FAB) m/z 452. Anal. (C, H, N) C<sub>21</sub>H<sub>23</sub>N<sub>3</sub>O<sub>4</sub>Cl<sub>2</sub>·HCl.

**Example 66**

15 **2-(4-Methylsulfonylphenyl)-N-methyl-N-([1S]-1-phenyl-2-[1-(3S)-(3-hydroxypyrrolidinyl)]ethyl)acetamide (25, ADL-01-0064-4)**

- ADL-01-0064-4 was prepared from 20 (0.2 g, 0.91 mmol), 4-methylsulfonylphenylacetic acid (0.41 g, 1.8 mmol), DCC (0.37 g, 1.8 mmol), pyridine (0.15 mL, 1.8 mmol), and NEt(iPr)<sub>2</sub> (0.48 mL, 2.7 mmol). The conditions are similar to those for the preparation of 21. After stirring at 25 °C overnight, more pyridine (0.075 mL, 0.9 mmol) and DCC (0.18 g, 0.9 mmol) were added, and the reaction was worked up the next day. The product was purified by radial chromatography eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub>:1% MeOH before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and washed with hot iPrOH to yield 25·HCl (0.15 g, 36%): m.p. (HCl salt) 240-241 °C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.8-2.4 (m, 2H, -CH<sub>2</sub>-), 2.8 (d, 3H, -NCH<sub>3</sub>, of cis and trans amide rotamers), 3.23 (s, 3H, -SO<sub>2</sub>CH<sub>3</sub>), 3.1-4.5 (m, 8H, 4 -CH<sub>2</sub>-), 5.5 (m, 1H, -CHOH), 6.15 (m, 1H, -CH-), 7.2-7.5 (m, 5H, aromatic), 7.55 (m, 2H, aromatic), 7.85 (m, 2H, aromatic). MS (FAB) m/z 417. Anal. (C, H, N) C<sub>22</sub>H<sub>25</sub>N<sub>3</sub>O<sub>4</sub>S·HCl.

**Example 67****2-(2-Nitro-4-trifluoromethylphenyl)-N-methyl-N-([1S]-1-phenyl-2-[1-(3S)-(3-hydroxypyrrolidinyl)]ethyl)acetamide (26, ADL-01-0067-7)**

- 30 With stirring at 25 °C under N<sub>2</sub>, DCC (0.39 g, 1.9 mmol) was added to a mixture of 2-nitro-4-trifluoromethylphenylacetic acid (0.47 g, 1.9 mmol) and pyridine (0.15 mL, 1.9 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (10 mL). After 5 min, a solution of 20 (0.4 g, 1.8 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (5 mL) was added. After 2 h, more DCC (0.1 g, 0.5 mmol) was added, and the mixture was stirred at 25 °C overnight before more 2-nitro-4-trifluoromethylphenylacetic acid (0.045 g, 0.18 mmol) and DCC (0.1 g, 0.5 mmol) were added. After 2 h, the reaction was worked up as in the preparation of 21. The product was purified by radial chromatography eluting with CH<sub>2</sub>Cl<sub>2</sub>:2% NH<sub>3</sub> before it was converted to the HCl salt with 1.0 M HCl in Et<sub>2</sub>O and precipitated from CH<sub>2</sub>Cl<sub>2</sub> to yield 26·HCl (0.050 g, 5.4%): <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.8-2.4 (m, 2H, -CH<sub>2</sub>-), 2.87 (s, 3H, -NCH<sub>3</sub>), 3.1-4.5 (complex, 8H, 4 -CH<sub>2</sub>-), 5.5 (m, 1H, -CHOH), 6.1 (m, 1H, -CH-), 7.2-7.5 (m, 5H, aromatic), 7.82 (d, J = 7.7 Hz, 1H, aromatic).

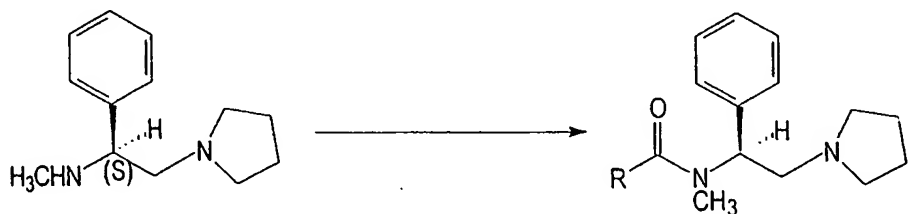
8.16 (d,  $J = 8$  Hz, 1H, aromatic), 8.42 (s, 1H, aromatic). MS (FAB)  $m/z$  452. Anal. (C, H, N)  $C_{22}H_{24}F_3N_3O_4 \cdot HCl \cdot 0.5H_2O$ .

### Example 68

#### 2-(2-Amino-4-trifluoromethylphenyl)-N-methyl-N-([1S]-1-phenyl-2-[1-(3S)-(3-hydroxypyrrolidinyl)ethyl]acetamide (27, ADL-01-0076-8)

ADL-01-0076-8 was prepared from 26 (0.14 g, 0.31 mmol), Raney nickel, and hydrazine hydrate (0.2 mL) in EtOH (14 mL). The conditions were similar to those used for the preparation of 9. The product was purified by radial chromatography eluting with  $CHCl_3$ :2%  $NH_3$ :2% MeOH before it was converted to the HCl salt with  $Et_3O \cdot HCl$  to yield 27HCl (0.11 g, 77%):  $^1H$  NMR ( $DMSO-d_6$ )  $\delta$  1.8-2.2 (m, 2H,  $-CH_2-$ ), 2.88 (s, 3H,  $-NCH_3$ ), 3.1-4.5 (complex, 9H, 4  $-CH_2-$  and 1  $-CHOH$ ), 6.2 (m, 1H,  $-CH-$ ), 6.8-7.5 (complex, 8 H, aromatic). MS (FAB)  $m/z$  423. Anal. (C, H, N)  $C_{22}H_{26}N_3O_2F_3 \cdot HCl \cdot 2.5H_2O$ .

Compounds of Examples 69-91 were prepared from the appropriate arylacetic acids/acid chlorides via EDCI/DIPEA or DCC/pyridine couplings, followed by reduction, deprotection, and/or derivatization via known chemistry. Intermediate A was prepared via the method reported in J. Med. Chem., 34, 1991 pp. 181-189, Costello, G.F. et al.



A

Compounds of Examples 69-91

### General procedure for EDCI/DIPEA coupling.

To a solution of acid(1.1eq.) and 1-Hydroxybenzotriazole hydrate(HOBT;1.1eq.) in dry  $CH_2Cl$  in an ice-bath under  $N_2$  was added 1-(3-Dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (EDCI;1.1eq.). The mixture was stirred for 30 minutes. A solution of the amine(1.0 eq.) in dry methylene chloride was added drop-wise followed by  $N,N$ -Diisopropylethyamine (DIPEA;1.5eq.). The solution was allowed to stir at room temperature overnight. The reaction was quenched with sat. sodium bicarbonate and separated from methylene chloride. The organic layer was dried ( $Na_2SO_4$ ), filtered through Celite, and evaporated. The crude product was chromatographed and converted to the HCl salt.

### Example 69

#### 2,2-Diphenyl-N-methyl-N-([1S]-1-phenyl-2-(1-pyrrolidinyl)ethyl)acetamide; ADL-01-0023-0

To a solution of Diphenylacetic acid(1.5g;7.3mmol) and pyridine(1.0mL;12.2mmol) in 20mL of dry methylene chloride at 25 degrees under  $N_2$  was added 1,3 dicyclohexylcarbodiimide, DCC(2.0g;9.8mmol). After 5 minutes, 28(1.0g;4.9mmol) in 20mL of dry methylene chloride



was added and the mixture was stirred overnight. TLC(95:5 methylene chloride:methanol with 2% ammonia) indicated all of the starting material was consumed. The reaction was quenched with sat. sodium bicarbonate and filtered through a Celite plug. The plug was rinsed with methylene chloride and the aqueous layer was extracted with methylene chloride.

5 The combined organic layers were dried ( $\text{Na}_2\text{SO}_4$ ), filtered and concentrated *in vacuo* to give 2.2g of a light brown solid. The crude product was purified by flash chromatography using a stepwise gradient of 2% to 8% MeOH: methylene chloride with 2% ammonia to afford 1.7g(88%) of pure product which was treated with 1.0M HCl in diethyl ether to give 29 as the HCl salt.  $^1\text{H}$  NMR (HCl salt, DMSO- $d_6$ )  $\delta$  2.0(br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 2.7(s, 3H,  $-\text{NCH}_3$ ), 6.2(br m, 1H,  $-\text{CH}-$ ), 7.1-7.5(complex, 15H, aromatic). MS (FAB)  $m/z$  398. Anal.(C,H,N)  $\text{C}_{27}\text{H}_{30}\text{N}_2\text{O} \cdot \text{HCl} \cdot 0.75\text{H}_2\text{O}$ .

10

#### Example 70

##### $\text{N}',\text{N}'$ -Diphenyl-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]urea; ADL-01-0027-1

15 To a 0 degree solution of 28(500mg;2.4mmol) and triethylamine(731mL;5.2mmol) in 10mL of dry methylene chloride under  $\text{N}_2$  was added a solution of Diphenylcarbonyl chloride(629mg;2.7mmol) in 5mL of dry methylene chloride. The solution was warmed to room temperature and stirred overnight. TLC(95:5 methylene chloride: methanol with 2% ammonia) indicated the starting material was consumed. The reaction solution was concentrated to a residue, which was pre-adsorbed onto silica and purified using a stepwise gradient of 2% to 7% MeOH: methylene chloride with 2% ammonia to afford 350mg(36%) of pure product which was treated with 1.0M HCl in diethyl ether to give 30 as the HCl salt.  $^1\text{H}$  NMR (HCl salt, DMSO- $d_6$ )  $\delta$  2.0 (br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 2.5(s, 3H,  $-\text{NCH}_3$ ), 5.8(br,m, 1H,  $-\text{CH}-$ ), 7.1-7.5(complex, 15H, aromatic). MS(FAB)  $m/z$  399. Anal.(C,H,N)  $\text{C}_{26}\text{H}_{29}\text{N}_3\text{O} \cdot \text{HCl} \cdot 0.5\text{H}_2\text{O}$ .

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25

#### Example 71

##### 2-(2-Nitrophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0030-5

30 ADL-01-0030-5 was prepared via the procedure described in the preparation of 29 from 28(0.6g;2.9mmol), 2-nitrophenylacetic acid (0.8g;4.4mmol), DCC(1.2g;5.8mmol), and pyridine(0.1mL;1.4mmol). The crude product was purified by flash chromatography using a stepwise gradient of 2% to 7% MeOH: methylene chloride with 2% ammonia to afford 0.2g(20%) of pure product which was treated with 1.0M HCl in diethyl ether to give 31 as the HCl salt.  $^1\text{H}$  NMR(HCl salt, DMSO- $d_6$ )  $\delta$  2.0(br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 2.9(s, 3H,  $-\text{NCH}_3$ ), 6.1(br,m, 1H,  $-\text{CH}-$ )7.3-8.1(complex, 9H, aromatic). MS(FAB)  $m/z$  367. Anal. (C,H,N)  $\text{C}_{21}\text{H}_{25}\text{N}_3\text{O}_3 \cdot \text{HCl}$ .

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#### Example 72

##### 2-(2-Nitro-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0033-9

45 ADL-01-0033-9 was prepared via the general EDCI/DIPEA coupling procedure from 28 (1.4g; 6.9mmol), 2-nitro 4,5-dichlorophenylacetic acid (1.9g; 7.6mmol), HOBT

(1.0g;7.6mmol), EDCI(1.4g;7.6mmol), and pyridine(0.8mL;10.3mmol). The crude product was purified by flash chromatography using a stepwise gradient of 2% to 5% MeOH: methylene chloride with 2% ammonia to afford 2.0g(60%) of pure product which was treated with 1.0M HCl in diethyl ether to give 32 as the HCl salt. <sup>1</sup>H NMR(HCl salt, DMSO-d<sub>6</sub>) δ 2.0(br, s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(s, 3H, -NCH<sub>3</sub>), 6.1(br, m, 1H, -CH-), 7.2-7.6(complex, 5H, aromatic), 7.9(s, 1H, aromatic), 8.4(s, 1H, aromatic). MS(FAB) m/z 436. Anal. (C,H,N) C<sub>21</sub>H<sub>23</sub>N<sub>3</sub>O<sub>3</sub>Cl<sub>2</sub>·HCl·0.25 H<sub>2</sub>O.

10

**Example 73****2-(4-Methylsulfonylphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0036-2**

ADL-01-0036-2 was prepared via the general EDCI/DIPEA coupling procedure from 28 (432mg;2.3mmol), 4-Methylsulfonylphenylacetic acid(500mg;2.3mmol), HOBT (341mg;2.5mmol), EDCI(483mg;2.5mmol),and DIPEA(550mL;3.1mmol). The crude product was purified by flash chromatography using a stepwise gradient of 2% to 4% MeOH: methylene chloride with 2% ammonia to afford 160mg(19%) of pure product which was treated with 1.0M HCl in diethyl ether to give 33 as the HCl salt. <sup>1</sup>H NMR(HCl salt, DMSO-d<sub>6</sub>) δ 2.0(br, s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(s, 3H, -NCH<sub>3</sub>), 3.2(s, -SO<sub>2</sub>CH<sub>3</sub>), 6.1(br, m, 1H, -CH-), 7.3-7.5(complex, 5H, aromatic), 7.6(br, d, 2H, aromatic), 7.9(br, d, 2H, aromatic). MS(FAB) m/z 400. Anal. (C,H,N) C<sub>22</sub>H<sub>28</sub>N<sub>2</sub>O<sub>3</sub>S·HCl·0.5 H<sub>2</sub>O.

25

**Example 74****2-(2-Methoxyphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0049-5**

ADL-01-0049-5 was prepared via the general EDCI/DIPEA coupling procedure from 28 (500 mg; 2.4 mmol), 2-Methoxyphenylacetic acid (610 mg; 3.6 mmol), HOBT (495 mg; 3.6 mmol), EDCI (700 mg; 3.6 mmol), and DIPEA (850 mL; 4.8 mmol). The crude product was purified by flash chromatography using a stepwise gradient of 1% to 7% MeOH: methylene chloride with 2% ammonia to afford 822mg(96%) of pure product which was treated with 1.0M HCl in diethyl ether to give 34 as the HCl salt. <sup>1</sup>H NMR (free base, CDCl<sub>3</sub>) δ 1.8(br, s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.8(s, 3H, -NCH<sub>3</sub>), 3.8(s, 3H, OCH<sub>3</sub>), 6.1(br, m, 1H, -CH-), 6.8-7.4(complex, 9H, aromatic). MS(FAB) m/z 352. Anal. (C,H,N) C<sub>22</sub>H<sub>28</sub>N<sub>2</sub>O<sub>2</sub>·HCl.

40

**Example 75****2-(3-Indolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0054-5**

ADL-01-0054-5 was prepared via the general EDCI/DIPEA coupling procedure from 28(500mg;2.4mmol), Indole-3-acetic acid(641mg;3.6mmol), HOBT(494mg;3.6mmol), EDCI(700mg;3.6mmol),and DIPEA(637mL;3.6mmol).The crude product was purified by flash chromatography using a stepwise gradient of 1% to 7% MeOH: methylene chloride to afford 761mg(88%) of pure product which was treated with 1.0M HCl in diethyl ether to give

35 as the HCl salt. <sup>1</sup>H NMR(HCl salt, CD<sub>3</sub>OD) δ 2.1(br, s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.8(s, 3H, -NCH<sub>3</sub>), 6.3(br, m, 1H, -CH-), 7.1-7.7(complex, 9H, aromatic). MS(FAB) m/z 361. Anal. (C,H,N) C<sub>23</sub>H<sub>27</sub>N<sub>3</sub>O.HCl.1.0 H<sub>2</sub>O.

5

**Example 76****2-(a,a,a-Trifluoro-p-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0058-6**

- 10 ADL-01-0058-6 was prepared via the general EDCI/DIPEA coupling procedure from 28(200mg; 0.9mmol), (a,a,a-Trifluoro-p-tolyl) acetic acid (239mg;1.1mmol), HOBT(157mg;1.1mmol), EDCI(223mg;1.1mmol), and DIPEA(203mL;1.1mmol).The crude product was purified by flash chromatography using a stepwise gradient of 1% to 2% MeOH: methylene chloride to afford 354mg(93%) of pure product which was treated with 1.0M HCl
- 15 in diethyl ether to give 36 as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 1.8(br, s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 3.0(s, 3H, NCH<sub>3</sub>), 6.4(br, m, 1H, CH), 7.2-7.6(complex, 9H, aromatic). MS(FAB) m/z 390. Anal. (C,H,N) C<sub>22</sub>H<sub>25</sub>N<sub>2</sub>OF<sub>3</sub>.HCl.

20

**Example 77****2-(2-Nitro-a,a,a-Trifluoro-4-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0062-8**

- 25 ADL-01-0062-8 was prepared via the general EDCI/DIPEA coupling procedure from 28(500mg;2.4mmol), (2-Nitro-a,a,a-trifluoro-4-tolyl)acetic acid(728mg;2.9mmol), HOBT(395mg;2.9mmol),EDCI(559mg;2.9mmol), and DIPEA(510mL;2.9mmol).The crude product was purified by flash chromatography using a stepwise gradient of 2% to 10% MeOH:methylene chloride to afford 786mg(74%) of pure product which was treated with 1.0M HCl in diethyl ether to give 37 as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.0(br, s,
- 30 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(s, 3H, -NCH<sub>3</sub>), 6.3(br, m, 1H, CH), 7.1-7.5(complex, 4H, aromatic), 7.8-7.9(br, m, 2H, aromatic), 8.3-8.4(br, s, 2H, aromatic). MS(FAB) m/z 435. Anal. (C,H,N) C<sub>22</sub>H<sub>24</sub>N<sub>3</sub>O<sub>3</sub>F<sub>3</sub>.HCl.

35

**Example 78****2-(1-[4-Chlorobenzoyl]-5-methoxy-2-methyl indole)-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0078-4**

- 40 ADL-01-0078-4 was prepared via the general EDCI/DIPEA coupling procedure from 28(100mg;0.4mmol), (1-[p-chlorobenzoyl]-5-methoxy-2-methyl indole-3-acetic acid (189mg;0.5mmol),HOBT(73mg;0.5mmol), EDCI(101mg;0.5mmol), and DIPEA (128mL;0.7mmol). The crude product was purified by flash chromatography using a stepwise gradient of 2% to 5% MeOH:methylene chloride to afford 200mg(79%) of pure product which was treated with 1.0M HCl in diethyl ether to give 38 as the HCl salt. <sup>1</sup>H
- 45 NMR(HCl salt, CDCl<sub>3</sub>) δ 1.6-1.8(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.3(b, s, 3H, -CH<sub>3</sub>), 2.9(br, s, -NCH<sub>3</sub>), 3.8(br, s, 3H, -OCH<sub>3</sub>), 6.7(br, m, 1H, -CH), 7.1-7.6(complex, 12H; aromatic). MS(FAB) m/z 509. Anal. (C,H,N) C<sub>32</sub>H<sub>35</sub>N<sub>3</sub>O<sub>3</sub>Cl.HCl.

**Example 79****2-(4-Nitrophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide;**  
**ADL-01-0079-2**

5 ADL-01-0079-2 was prepared via the general EDCI/DIPEA coupling procedure from 28(1.5g;7.3mmol), 4-Nitrophenylacetic acid(2.0g;11.0mmol), HOBT(1.4g;11.0mmol), EDCI(2.1g;11.0mmol),and DIPEA(2.5mL;14.6mmol).The crude product was purified by  
10 flash chromatography using a stepwise gradient of 1%to 5% MeOH: methylene chloride to afford 2.5g(93%) of pure product which was treated with 1.0M HCl in diethyl ether to give 39 as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 1.6(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.8(br, s, 3H, -NCH<sub>3</sub>), 6.4(br, m, 1H, -CH), 7.1-7.5(complex, 7H, aromatic), 8.0(br, d, 2h, aromatic). MS (FAB) m/z 367. Anal. (C,H,N) C<sub>21</sub>H<sub>25</sub>N<sub>3</sub>O<sub>3</sub>.HCl.

15

**Example 80****2-(3-Nitrophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide;**  
**ADL-01-0084-2**

20 ADL-01-0084-2 was prepared via the general EDCI/DIPEA coupling procedure from 28(1.5g;7.3mmol), 3-Nitrophenylacetic acid(2.0g;11.0mmol), HOBT(1.4g;11.0mmol), EDCI(2.1g;11.0mmol),and DIPEA(2.5mL;14.6mmol). The crude product was purified by  
25 flash chromatography using a stepwise gradient of 1% to 5% MeOH:methylene chloride with 2% ammonia to afford 2.6g(100%) of pure product which was treated with 1.0M HCl in diethyl ether to give 40 as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.0(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(br, s, 3H, -NCH<sub>3</sub>), 6.3(br, m, 1H, -CH), 7.2-7.6(complex, 6H, aromatic), 7.8(br, d, 1H, aromatic), 8.1-8.2(complex, 2H, aromatic). MS(FAB) m/z 367. Anal. (C,H,N) C<sub>21</sub>H<sub>25</sub>N<sub>3</sub>O<sub>3</sub>.HCl. 0.5 H<sub>2</sub>O.

30

**Example 81****2-(2-Pyridyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide;**  
**ADL-01-0085-9**

35

ADL-01-0085-9 was prepared via the general EDCI/DIPEA coupling procedure from 28(350mg;1.7mmol),2-Pyridylacetic acid hydrochloride(326mg;1.8mmol), HOBT (253mg;1.8mmol), EDCI(360mg;1.8mmol) and DIPEA(644mL;3.7mmol). The crude  
40 product was purified by flash chromatography using a stepwise gradient of 2% to 5% MeOH: methylene chloride with 2% ammonia to afford 400mg(72%) of pure product which was treated with 1.0m HCl in diethyl ether to give 41 as the HCl salt. <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>) δ 1.7-1.9(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.8(br, s, 3H, -NCH<sub>3</sub>), 6.0-6.2(br, m, 1H, -CH), 7.1-7.8(complex, 8H, aromatic), 8.5(br, d, 1H, aromatic). MS(FAB) m/z 323. Anal. (C,H,N) C<sub>20</sub>H<sub>25</sub>N<sub>3</sub>O. 2 HCl. 0.5H<sub>2</sub>O.

45

**Example 82****2-(3-Pyridyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide;**  
**ADL-01-0100-6**

5  
ADL-01-0100-6 was prepared via the general EDCI/DIPEA coupling procedure from 28  
(120mg;0.5mmol), 3-Pyridylacetic acid hydrochloride  
(110mg;0.6mmol), HOBT(85mg;0.6mmol), EDCI (120mg;0.6mmol), and DIPEA  
10 (280mL;1.5mmol). The crude product was purified by flash chromatography using a  
stepwise gradient of 1% to 6% MeOH:methylene chloride with 2% ammonia to afford  
142mg(76%) of pure product which was treated with 1.0M HCl in diethyl ether to give 42 as  
the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.1(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(br, s, 3H, -NCH<sub>3</sub>),  
6.2-6.3(br, m, 1H, -CH), 7.2-7.3(complex, 5H, aromatic), 7.8-7.9(br, t, 1H, aromatic), 8.6-  
8.9(complex, 3H, aromatic). MS(FAB) m/z 323. Anal. (C,H,N) C<sub>20</sub>H<sub>25</sub>N<sub>3</sub>O<sub>2</sub>.HCl.1.25 H<sub>2</sub>O.

**Example 83****2-((+)-6-Methoxy-a-methyl-2-naphthalene)-N-[(1S)-1-phenyl-2-(1-**  
**pyrrolidinyl)ethyl]acetamide; ADL-01-0110-5**

20  
ADL-01-0110-5 was prepared via the general EDCI/DIPEA coupling procedure from  
28(200mg;0.9mmol), (+)-6-Methoxy-a-methyl-2-naphthaleneacetic acid(217mg;1.0mmol),  
HOBT (142mg;1.0mmol), EDCI(201mg;1.0mmol), and DIPEA(256mL;1.4mmol). The  
25 crude product was purified by flash chromatography using a stepwise gradient of 1% to 2%  
MeOH:methylene chloride with 2% ammonia to afford 130mg(33%) of pure product which  
was treated with 1.0M HCl in diethyl ether to give 43 as the HCl salt. <sup>1</sup>H NMR(HCl salt,  
CDCl<sub>3</sub>) δ 1.4(d, 3H, -CH<sub>3</sub>), 2.9(br, s, -NCH<sub>3</sub>), 3.9(s, -OCH<sub>3</sub>), 5.5(br, m, 1H, -CH), 7.0-  
7.7(complex, 11H, aromatic). MS(FAB) m/z 416. Anal. (C,H,N) C<sub>27</sub>H<sub>32</sub>N<sub>2</sub>O<sub>2</sub>.HCl. 0.25 H<sub>2</sub>O.

**Example 84****2-(a,a,a-Trifluoro-3-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide;**  
**ADL-01-0111-3**

35  
ADL-01-0111-3 was prepared via the general EDCI/DIPEA coupling procedure from 28  
(200mg;0.9mmol), (a,a,a-Trifluoro-m-tolyl)acetic acid(214mg;1.0mmol), HOBT  
(142mg;1.0mmol), EDCI(201mg;1.0mmol), and DIPEA(256mL;1.4mmol). The crude  
40 product was purified by flash chromatography using a stepwise gradient of 2% to 6%  
MeOH:methylene chloride to afford 250mg(67%) of pure product which was treated with  
1.0M HCl in diethyl ether to give 44 as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.0(br, m,  
4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(br, s, 3H, -NCH<sub>3</sub>), 6.4(br, m, 1H), 7.1-7.7(complex, 9H, aromatic). MS  
(FAB) m/z 390. Anal. (C,H,N) C<sub>22</sub>H<sub>23</sub>N<sub>2</sub>OF<sub>3</sub>.HCl.

**Example 85****2-(4-Pyridyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide;****ADL-01-0122-0**

5  
ADL-01-0122-0 was prepared via the general EDCI/DIPEA coupling procedure from 28  
(120mg;0.5mmol), 4-Pyridylacetic acid hydrochloride(150mg;0.8mmol), HOBT  
(117mg;0.8mmol), EDCI(166mg;0.8mmol), and DIPEA(202mL;1.1mmol). The crude  
product was purified by flash chromatography using a stepwise gradient of 2% to 5%  
10 MeOH:methylene chloride to afford 172mg(92%) of pure product which was treated with  
1.0M HCl in diethyl ether to give 45 as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.1(br, m,  
4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(br, s, -NCH<sub>3</sub>), 6.3(br, m, -CH), 7.2-7.3(complex, 5H, aromatic), 7.8(br, s,  
2H, aromatic), 8.6(br, s, 2H, aromatic). MS (FAB) m/z 323. Anal. (C,H,N) C<sub>20</sub>H<sub>25</sub>N<sub>3</sub>O.1.5  
HCl. 0.5 H<sub>2</sub>O.

**Example 86****2-(a,a,a-Trifluoro-2-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide;****ADL-01-0123-8**

20  
ADL-01-0123-8 was prepared via the general EDCI/DIPEA coupling procedure from  
28(200mg;0.9mmol), (a,a,a-Trifluoro-o-tolyl)acetic acid(239mg;1.1mmol), HOBT(157mg;  
1.1mmol), EDCI(223mg;1.1mmol), and DIPEA(203mL;1.1mmol). The crude product was  
purified by flash chromatography using a stepwise gradient of 1% to 4% MeOH:methylene  
25 chloride with 2% ammonia to afford 339mg(82%) of pure product which was treated with  
1.0M HCl in diethyl ether to give 46 as the HCl salt. <sup>1</sup>H NMR (HCl salt, CDCl<sub>3</sub>) δ 2.0(br, m,  
4H-CH<sub>2</sub>CH<sub>2</sub>-), 2.9(br, s, -NCH<sub>3</sub>), 6.3(br, m, 1H, -CH), 7.1-7.7(complex, 9H, aromatic). MS  
(FAB) m/z 390. Anal. (C,H,N) C<sub>22</sub>H<sub>25</sub>N<sub>3</sub>OF<sub>3</sub>. HCl.

**Example 87****2-((S)-(+)-4-Isobutyl-a-methylphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-  
pyrrolidinyl)ethyl]acetamide; ADL-01-0125-3**

35  
ADL-01-0125-3 was prepared via the general EDCI/DIPEA coupling procedure from  
28(200mg; 0.9mmol), (S)-(+)-4-Isobutyl-a-methylphenylacetic acid(217mg; 1.0mmol),  
HOBT (142mg; 1.0mmol), EDCI(201mg;1.0mmol), and DIPEA(256mL;1.4mmol). The  
crude product was purified by flash chromatography using a stepwise gradient of 1% to 2%  
40 MeOH:methylene chloride with 2% ammonia to afford 240mg(66%) of pure product which  
was treated with 1.0M HCl in diethyl ether to give 47 as the HCl salt. <sup>1</sup>H NMR(HCl salt,  
CDCl<sub>3</sub>) δ 0.8(d, 6H, -(CH<sub>3</sub>)<sub>2</sub>), 1.4(d, 2H, -CH<sub>3</sub>), 2.0(br, m, -CH<sub>2</sub>CH<sub>2</sub>-), 2.3-2.4(d, 2H, -CH<sub>2</sub>-),  
2.9(s, 3H, -NCH<sub>3</sub>), 5.6(br, m, 1H, -CH), 7.0(br, q, 4H, aromatic), 7.3(br, s, 5H, aromatic).  
MS(FAB) m/z 392. Anal. (C, H, N) C<sub>26</sub>H<sub>36</sub>N<sub>2</sub>O. HCl. 0.25 H<sub>2</sub>O.

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**Example 88****2-(3,4,5-Trimethoxyphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0146-9**

ADL-01-0146-9 was prepared via the general EDCI/DIPEA coupling procedure from 28(250mg;1.2mmol), 3,4,5-Trimethoxyphenylacetic acid(304mg;1.3mmol), HOBT(181mg; 1.3mmol), EDCI(256mg;1.3mmol), and DIPEA(318mL;1.8mmol). The crude product was purified by flash chromatography using a stepwise gradient of 2% to 5% MeOH:methylene chloride with 2% ammonia to afford 500mg(100%) of pure product which was treated with 1.0M HCl in diethyl ether to give 48 as the HCl salt. <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>) δ 1.7(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.7(s, 3H, -NCH<sub>3</sub>), 3.8(d, 9H, -OCH<sub>3</sub>), 6.0-6.2(br, m, 1H, -CH), 6.4(s, 2H, aromatic), 7.1-7.3(complex, 5H, aromatic). MS (FAB) m/z 412. Anal. (C,H,N) C<sub>24</sub>H<sub>32</sub>N<sub>2</sub>O<sub>4</sub>·HCl.

**Example 89****2-(2-Aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide ADL-01-0024-8**

Raney-Nickel(50% slurry in water) was added to a mixture of 31(2.30g;6.1mmol), 2.2mL(61.9mmol) of hydrazine hydrate and 45mL of abs. EtOH at 55 degrees to maintain a regular gas evolution. After 45 min., TLC(95:5 methylene chloride:methanol w/2% ammonia) indicated that all of the starting material was consumed. The mixture was filtered through a Celite plug and rinsed with copious amounts of hot methanol. The filtrates were combined and concentrated *in vacuo* to afford 270 mg of a waxy solid. The crude product was purified by flash chromatography using a stepwise gradient of 1% to 8% methanol:methylene chloride with 2% ammonia to afford 2.01g(97%) of desired product. The pure product was treated with 1.0M HCl in diethyl ether to yield 49(ADL-01-0024-8) as the HCl salt. <sup>1</sup>H NMR(HCl salt, DMSO-d<sub>6</sub>) δ 2.0(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(s, 3H, -NCH<sub>3</sub>), 6.1(br, m, 1H, -CH), 7.2(complex, 9H, aromatic). MS (FAB) m/z 321. Anal. (C,H,N) C<sub>21</sub>H<sub>27</sub>N<sub>3</sub>O·2HCl·0.75 H<sub>2</sub>O.

**Example 90****2-(2-N,N-Dimethylsulfonamido-2-aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0060-2**

To a solution of 49(400 mg;1.1mmol) in 50ml of dry methylene chloride was added 429mL of triethylamine and MsCl(913mL; 11.8mmol) dissolved in 6mL of dry methylene chloride. The dark red solution was allowed to stir overnight. TLC(95:5 methylene chloride:methanol w/2% ammonia) indicates the starting material is consumed. The reaction solution was quenched with sat. sodium bicarbonate and the layers were separated. The aqueous layer was extracted with methylene chloride and the combined organic layers were dried over anh. sodium sulfate, filtered and the solvent was concentrated *in vacuo* to give 700 mg of a dark brown residue. The crude product was purified by flash chromatography using a stepwise gradient of 2% to 7% methanol:methylene chloride with 2% ammonia to afford 580mg(97%)

of desired product. The pure product was treated with 1.0M HCl in diethyl ether to yield 50(ADL-01-0060-2) as the HCl salt. <sup>1</sup>H NMR(HCl salt, DMSO-d<sub>6</sub>) δ 2.0(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.7(br, s, 3H, -NCH<sub>3</sub>), 3.5(br, s, (-SO<sub>2</sub>CH<sub>3</sub>)<sub>2</sub>), 6.2(br, d, 1H, -CH), 7.2-7.5(complex, 9H, aromatic). MS (FAB) m/z 493. Anal. (C<sub>23</sub>H<sub>31</sub>N<sub>3</sub>O<sub>5</sub>S<sub>2</sub>·HCl. 0.25 H<sub>2</sub>O.

#### Example 91

##### 2-(N-Methylsulfonamido-2-aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0075-0

10

To a solution of 50(500mg;1.0mmol) in 6mL of 2:1 MeOH:THF was added 4.0mL of 1.0M NaOH. The solution was stirred for 20 min., after which TLC(95:5 methylene chloride:methanol w/2% ammonia) indicates the reaction is complete. The reaction was quenched with 10% HCl and washed with water and brine. The organic layer was dried over anhydrous sodium sulfate, filtered and concentrated *in vacuo* to give 381mg of a brown solid. The crude product was purified by flash chromatography using a stepwise gradient of 2% to 4% methanol: methylene chloride with 2% ammonia to afford 326mg(80%) of desired product. The pure product was treated with 1.0M HCl in diethyl ether to yield 51(ADL-01-0075-0) as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.0(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(br, s, 3H, -NCH<sub>3</sub>), 3.0(s, 3H, -SO<sub>2</sub>CH<sub>3</sub>), 6.3(br, m, 1H, -CH), 7.0-7.2(complex, 8H, aromatic), 7.5(br, d, 1H, aromatic). MS (FAB) m/z 415. Anal. (C<sub>22</sub>H<sub>29</sub>N<sub>3</sub>O<sub>3</sub>S·HCl. 0.25 H<sub>2</sub>O.

20

#### Example 92

##### 2-(2-Amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0035-4

25

To a solution of 32(495mg;1.0mmol) in 25mL of abs. EtOH was added 50mg of 10% Pd/C. The mixture was placed on a Parr apparatus under 10psi of hydrogen. After 1h, TLC(95:5 methylene chloride:methanol) indicates no starting material remains. The mixture was filtered through a Celite plug and basified with aq. ammonium hydroxide. The solvent was concentrated *in vacuo* to get a residue which was dissolved in EtOAc and washed repeatedly with water. The organic layer was dried over anhydrous sodium sulfate, filtered and concentrated to give 200mg of crude free base. The crude product was treated with 1.0M HCl in diethyl ether and dried in a vacuum oven @80 degrees overnight to recover 120mg(30%) of 52(ADL-01-0035-4) as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 1.6-1.7(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.7(s, 3H, -NCH<sub>3</sub>), 5.9-6.1(br, m, 1H, -CH), 7.1-7.2(complex, 7H, aromatic). MS (FAB) m/z 406. Anal. (C<sub>21</sub>H<sub>25</sub>N<sub>3</sub>OCl<sub>2</sub>·HCl. 1.5 H<sub>2</sub>O.

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#### Example 93

##### 2-(N,N-Dimethylsulfonamido-2-amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0050-3

Same procedure as 50 using 223 mg(0.54mmol) of 52, 0.5mL(6.4mmol) of MsCl, 2.0mL(14.3mmol) of triethylamine and 25mL of dry methylene chloride. The crude product was purified by flash chromatography using a stepwise gradient of 1% to 3% MeOH: methylene chloride to yield 150mg(49%) of pure product which was treated with 1.0M HCl

45



in diethyl ether to give 53(ADL-01-0050-3) as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.0(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.8(s, 3H, NCH<sub>3</sub>), 3.3(d, 6H, -(SO<sub>2</sub>CH<sub>3</sub>)<sub>2</sub>), 6.2(br, m, 1H, -CH), 7.0-7.1(complex, 2H, aromatic), 7.3(complex, 5H, aromatic). MS (FAB) m/z 562. Anal. (C,H,N) C<sub>23</sub>H<sub>29</sub>N<sub>3</sub>O<sub>5</sub>S<sub>2</sub>Cl<sub>2</sub>. HCl. 0.5 H<sub>2</sub>O.

5

#### Example 94

##### 2-(2-Amino,α,α,α-Trifluoro-4-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0068-5

10

Same procedure as 49 using 710mg(1.6mmol) of 37, 0.5mL(16.3mmol) of hydrazine hydrate in 50mL of EtOH. The recovered product, 650mg(98% crude recovery) was not purified any further. A small amount of the desired product was treated with 1.0M HCl in diethyl ether to form 54(ADL-01-0068-5) as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.0(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(br, s, 3H, -NCH<sub>3</sub>), 6.3(br, m, 1H, -CH), 7.2-7.5(complex, 8H, aromatic). MS (FAB) m/z 405. Anal. (C,H,N) C<sub>22</sub>H<sub>26</sub>N<sub>3</sub>OF<sub>3</sub>. 1.5 HCl.

15

#### Example 95

##### 2-(2-N,N-Dimethylsulfonamido-2-amino-a,a,a-trifluoro-4-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0069-3

20

Same procedure as 50 using 100mg(0.24mmol) of 54, 0.2mL(2.4mmol) of MsCl, 0.8mL(6.3mmol) of triethylamine and 13mL of dry methylene chloride. The crude product was purified by flash chromatography using a stepwise gradient of 1% to 5% MeOH: methylene chloride to yield 110mg(80%) of desired product. A small amount of compound was treated with 1.0M HCl in diethyl ether to give 55(ADL-01-0069-3) as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.0(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(s, 3H, -NCH<sub>3</sub>), 3.3(d, 6H, -(SO<sub>2</sub>CH<sub>3</sub>)<sub>2</sub>), 6.3(br, m, 1H, -CH), 7.1-8.0(complex, 8H, aromatic). MS (FAB) m/z 497. Anal. (C,H,N) C<sub>24</sub>H<sub>30</sub>N<sub>3</sub>OF<sub>3</sub>S<sub>2</sub>. HCl. 0.5 H<sub>2</sub>O.

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#### Example 96

##### 2-(N-Methylsulfonamido-2-amino-a,a,a-trifluoro-4-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0077-6

35

Same procedure as 51 using 51mg(0.1mmol) of 55, 30mL of 1.0M NaOH and 1.9mL of 2:1 MeOH:THF. The crude product was purified by flash chromatography using a stepwise gradient of 1% to 5% MeOH: methylene chloride with 2% ammonia to yield 27mg(63%) of pure product which was treated with 1.0M HCl in diethyl ether to form 56(ADL-01-0077-6) as the HCl salt. <sup>1</sup>H NMR(HCl salt, CDCl<sub>3</sub>) δ 2.0(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(br, s, 3H, -NCH<sub>3</sub>), 3.1(br, s, 3H, -SO<sub>2</sub>CH<sub>3</sub>), 7.1-7.3(complex, 8H, aromatic). MS (FAB) m/z 483. Anal. (C,H,N) C<sub>23</sub>H<sub>28</sub>N<sub>3</sub>O<sub>3</sub>SF<sub>3</sub>. HCl. 0.25 H<sub>2</sub>O.

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**Example 97****2-(2-Aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide;  
ADL-01-0089-1**

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Same procedure as 49 using 2.6g(7.1mmol) of 40, 2.5mL(80.2mmol) of hydrazine hydrate in 70mL of EtOH. The recovered product, 1.8g was purified by flash chromatography using a stepwise gradient of 1% to 9% MeOH: methylene chloride with 2% ammonia to yield 1.1g(47%) of pure product which was treated with 1.0M HCl in diethyl ether to give 10 57(ADL-01-0089-1) as the HCl salt. <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>) δ 1.7-1.9(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.7(s, 3H, -NCH<sub>3</sub>), 6.1(br, m, 1H, -CH), 6.5-6.8(complex, 3H, aromatic), 7.0(m, 2H, aromatic), 7.3(complex, 4H, aromatic). MS (FAB) m/z 337. Anal. (C,H,N) C<sub>21</sub>H<sub>27</sub>N<sub>3</sub>O. 2HCl. 0.5 H<sub>2</sub>O.

15

**Example 98****2-(4-Aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide;  
ADL-01-0103-0**

20

Same procedure as 49 using 2.3g(6.3mmol) of 39, 2.4mL(75.4mmol) of hydrazine hydrate in 70mL of EtOH. The recovered product, 1.7g was purified by flash chromatography using a stepwise gradient of 2% to 3% MeOH: methylene chloride with 2% ammonia to yield 1.53g(73%) of pure product. A small amount of compound was treated with 1.0M HCl in diethyl ether to give 25 58(ADL-01-0103-0) as the HCl salt. <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>) δ 1.8(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.7(s, 3H, -NCH<sub>3</sub>), 6.1(br, m, 1H, -CH), 6.7(m, 2H, aromatic), 7.0(d, 2H, aromatic), 7.3(complex, 5H, aromatic). MS (FAB) m/z 337. Anal. (C,H,N) C<sub>21</sub>H<sub>27</sub>N<sub>3</sub>O. 2HCl. 0.75 H<sub>2</sub>O.

30

**Example 99****2-(N,N-Dimethylsulfonamido-2-aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0112-1**

35

Same procedure as 50 using 500mg(1.5mmol) of 57, 1.1mL(14.8mmol) of MsCl, 3.0mL(22.2mmol) of triethylamine and 8.0mL of dry methylene chloride. The crude product was purified by flash chromatography using a stepwise gradient of 1% to 4% MeOH: methylene chloride with 2% ammonia to yield 308mg(42%) of pure product. A small amount of compound was treated with 1.0M HCl in diethyl ether to give 40 59(ADL-01-0112-1) as the HCl salt. <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>) δ 1.8(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.8(s, 3H, -NCH<sub>3</sub>), 3.4(s, 6H, (-SO<sub>2</sub>CH<sub>3</sub>)<sub>2</sub>), 6.1(br, m, 1H, -CH), 7.0-7.5(complex, 9H, aromatic). MS (FAB) m/z 493. Anal. (C,H,N) C<sub>23</sub>H<sub>31</sub>N<sub>3</sub>O<sub>5</sub>S<sub>2</sub>. HCl

45

**Example 100****2-(N,N-Dimethylsulfonamido-2-aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0127-9**

5 Same procedure as 50 using 400mg(1.2mmol) of 58, 0.55mL(7.1mmol) of MsCl, 1.6mL(11.8mmol) of triethylamine and 12.0ml of dry methylene chloride. The crude product was purified by flash chromatography using a stepwise gradient of 2% to 5% MeOH: methylene chloride with 2% ammonia to yield 395mg(68%) of pure product. The compound  
 10 was treated with 1.0M HCl in diethyl ether to give 60(ADL-01-0127-9) as the HCl salt. <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>) δ 1.8(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.8(s, 3H, -NCH<sub>3</sub>), 3.4(s, 6H, (-SO<sub>2</sub>CH<sub>3</sub>)<sub>2</sub>), 6.1(br, m, 1H, -CH), 7.0-7.5(complex, 9H, aromatic). MS (FAB) m/z 493. Anal. (C,H,N) C<sub>23</sub>H<sub>31</sub>N<sub>3</sub>O<sub>5</sub>S<sub>2</sub>.HCl. 0.25 H<sub>2</sub>O.

**Example 101****2-(2-Hydroxyphenyl)-N-methyl-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide; ADL-01-0061-0**

20 To a solution of 34(700mg;1.8mmol) in 10mL of dry methylene chloride @ -78 degrees was added 10.8mL(10.8mmol;1.0M solution of BBr<sub>3</sub> in methylene chloride) over 15 minutes. The reaction mixture was allowed to warm to room temperature and stir overnight. TLC(95:5 methylene chloride: MeOH w/2% ammonia) indicated no starting material remained. The reactionn was quenched with the addition of MeOH at 0 degrees. After 30 minutes, 3N HCl  
 25 was added and the mixture was stirred for 30 minutes(white precipitate seen). The mixture was made neutral with sat. bicarbonate and extracted with methylene chloride(3x100mL). The organic layer was dried over anh. sodium sulfate, filtered and concentrated *in vacuo* to give 610mg of crude product. The crude product was purified by flash chromatography using a stepwise gradient of 2% to 3% MeOH: methylene chloride to yield 500mg(82%) of pure  
 30 product. The product was treated with 1.0M HCl in diethyl ether to give 61(ADL-01-0061-0) as the HCl salt. <sup>1</sup>H NMR(free base, CDCl<sub>3</sub>) δ 1.7(br, m, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(s, 3H, -NCH<sub>3</sub>), 6.1(br, m, 1H, -CH), 6.8-7.4(complex, 9H, aromatic). MS (FAB) m/z 338. Anal. (C,H,N) C<sub>21</sub>H<sub>26</sub>N<sub>2</sub>O<sub>2</sub>.HCl. 0.5 H<sub>2</sub>O.

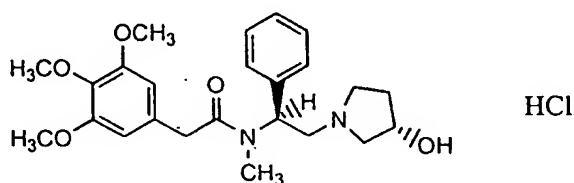
**Example 102****N-Methyl-N-[(1S)-1-phenyl-2-((3S)-3-hydroxypyrrolidine-1-yl)ethyl]-3,4,5-trimethoxyphenylacetamide HCl (A)****ADL-01-140-2**

40 To a solution of 3,4,5-trimethoxyphenylacetic acid (1.0 g, 4.43 mmol) in 10 mL of CH<sub>2</sub>Cl<sub>2</sub> under a nitrogen atmosphere was added pyridine (0.12 g, 1.5 mmol) and N,N-diisopropylethylamine (Hunig's Base) (0.57 g, 4.43 mmol). The reaction mixture was cooled to 0°C and DCC (1.37 g, 6.65 mmol) was added in one portion. The reaction mixture was  
 45 stirred at this temperature and a solution of the diamine (0.65 g, 3.0 mmol) in 10mL of CH<sub>2</sub>Cl<sub>2</sub> was added and the stirring was continued while warming to room temperature for 20 h. The reaction mixture was poured onto an aqueous saturated solution of NaHCO<sub>3</sub> and the

mixture was stirred for 30 min. The organic layer was separated and dried over anhydrous  $\text{Na}_2\text{SO}_4$ . After removal of the solvent, the product was purified on a silica gel column [solvent system:  $\text{CHCl}_3$ :  $\text{CH}_3\text{OH}$ :28% $\text{NH}_4\text{OH}$ (98:2:2)]. The free base was converted to the hydrochloride salt from 1M etherial HCl and recrystallized from  $\text{CH}_2\text{Cl}_2$ : $\text{Et}_2\text{O}$  (1:1) to give a

- 5 HCl 0.64 g (46%) as light pink solid; mp 230-232°C;  $^1\text{H-NMR}$  (200 MHz,  $\text{CDCl}_3$ )  $\delta$  2.20 (m, 4H), 2.85 (s, 3H), 3.00-4.30 (m, 5H), 3.70 (ms, 9H), 4.50 (m, 2H), 5.30 (d,  $J = 15.0$  Hz, 1H), 6.50 (m, 3H), 7.28 (m, 5H). Anal. Calcd for  $\text{C}_{24}\text{H}_{32}\text{N}_2\text{O}_5 \cdot \text{HCl} \cdot 0.25\text{H}_2\text{O}$ : C, 61.40; H, 7.19; N, 5.97. Found: C, 61.36; H, 6.84; 8.96; N, 5.91.

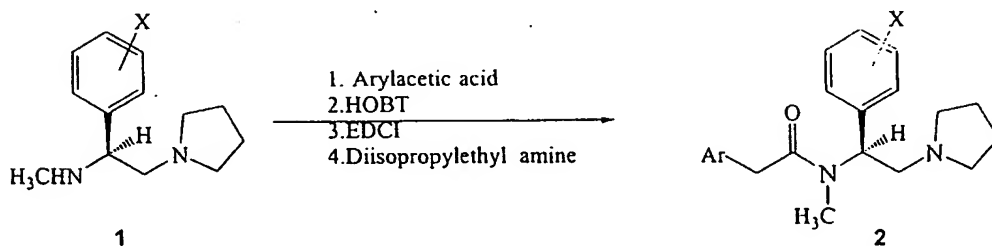
- 10 The structure of the compound is shown hereunder.



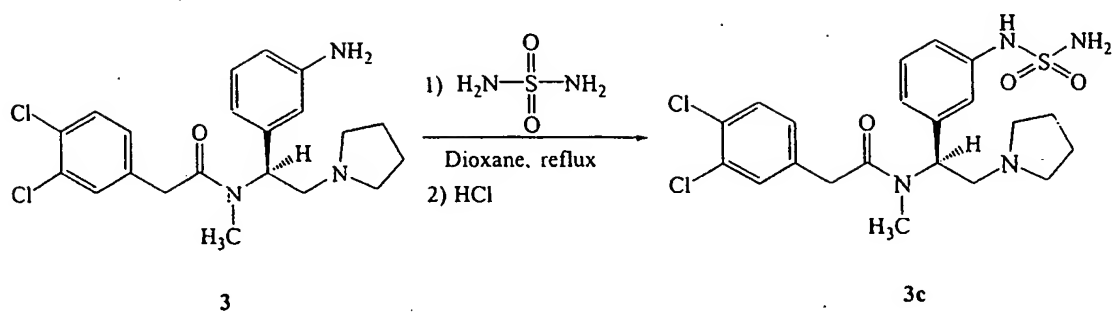
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The preparation of compounds of 3a through 3ddd of formula IIIA follow according to Schemes G, H, I, J, K, L, M, and N.

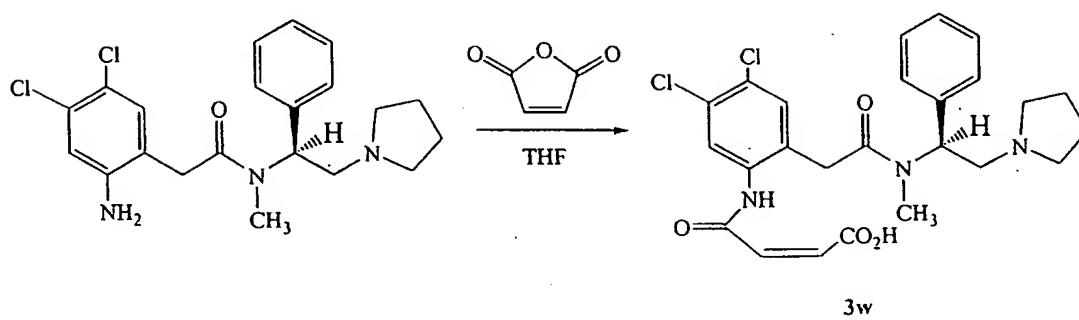
#### Scheme G



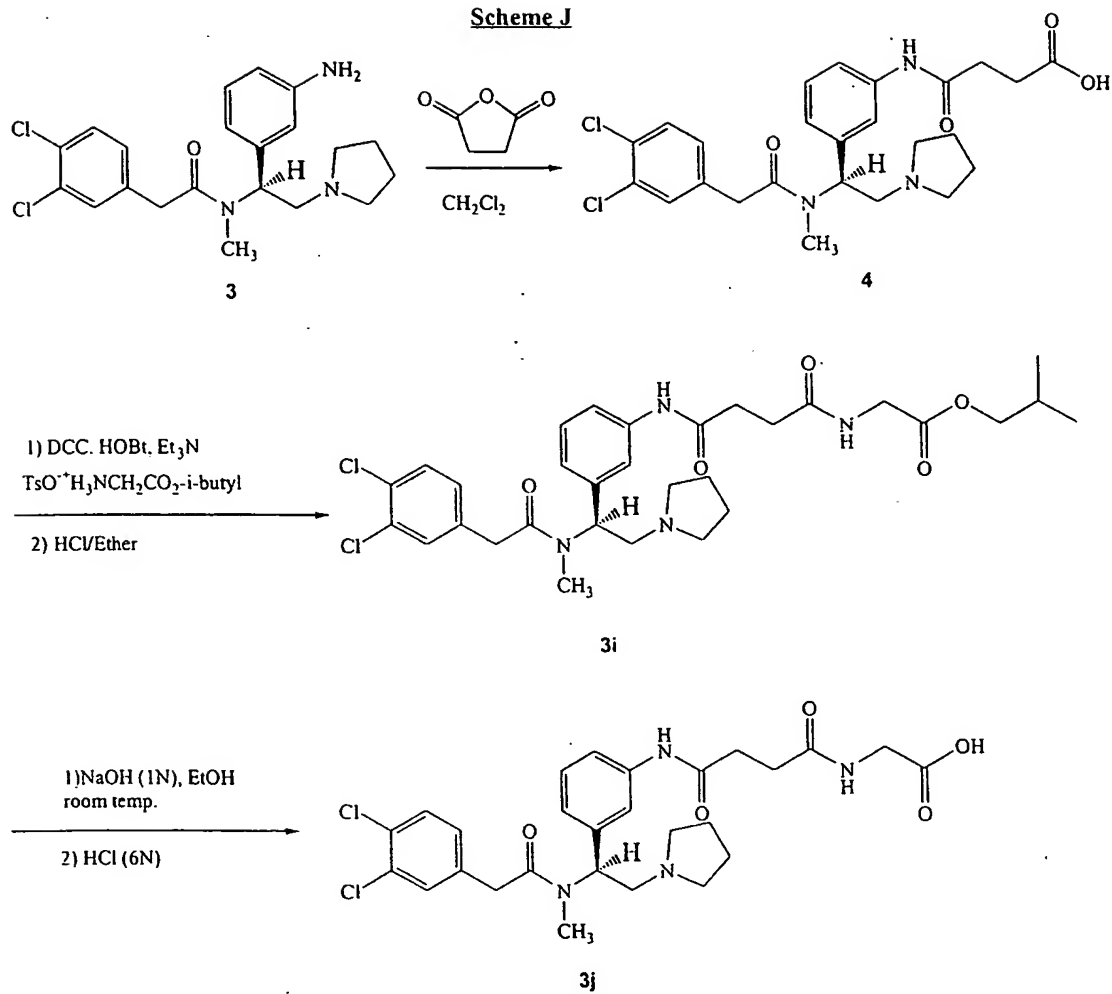
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**Scheme H**

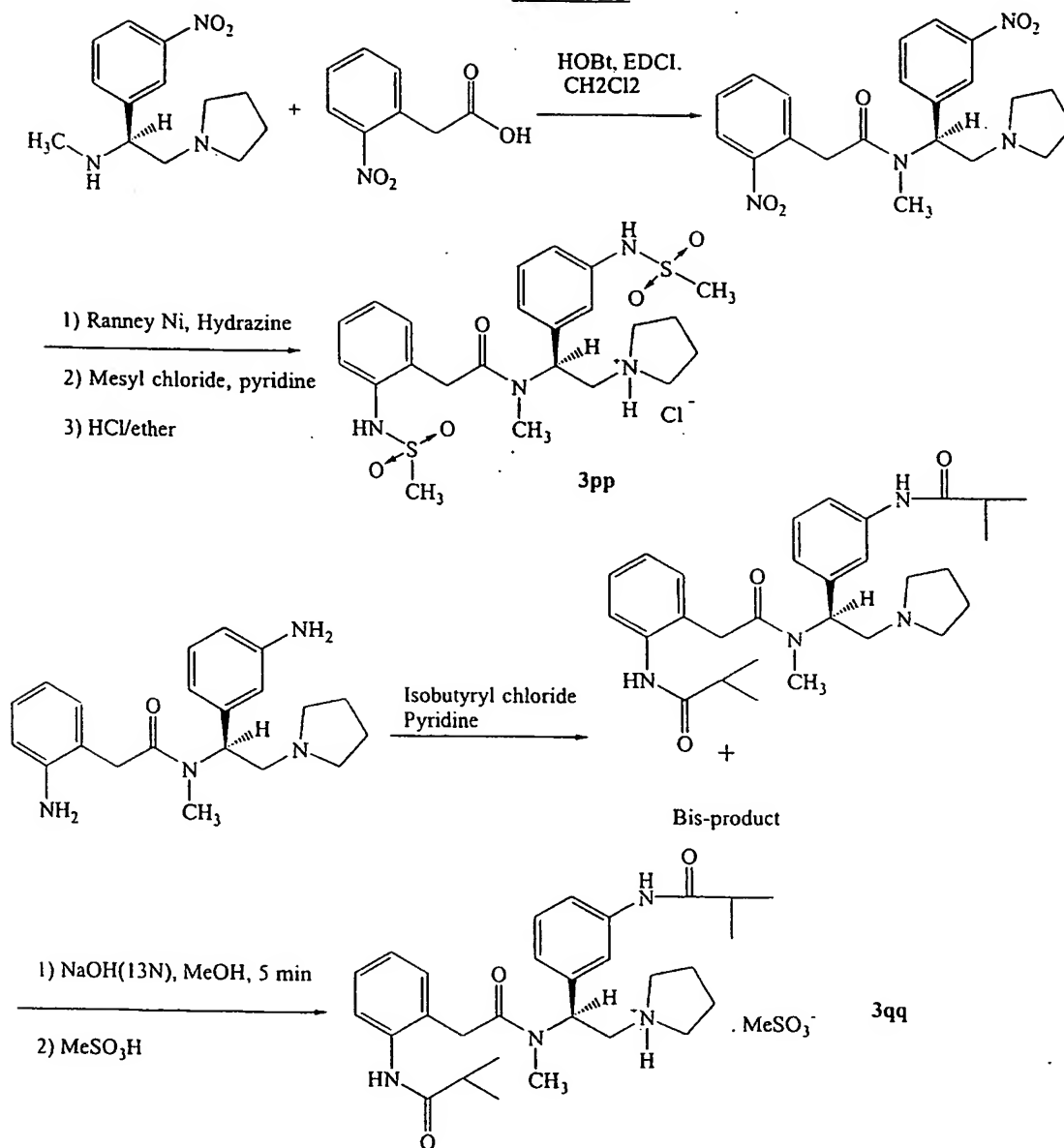
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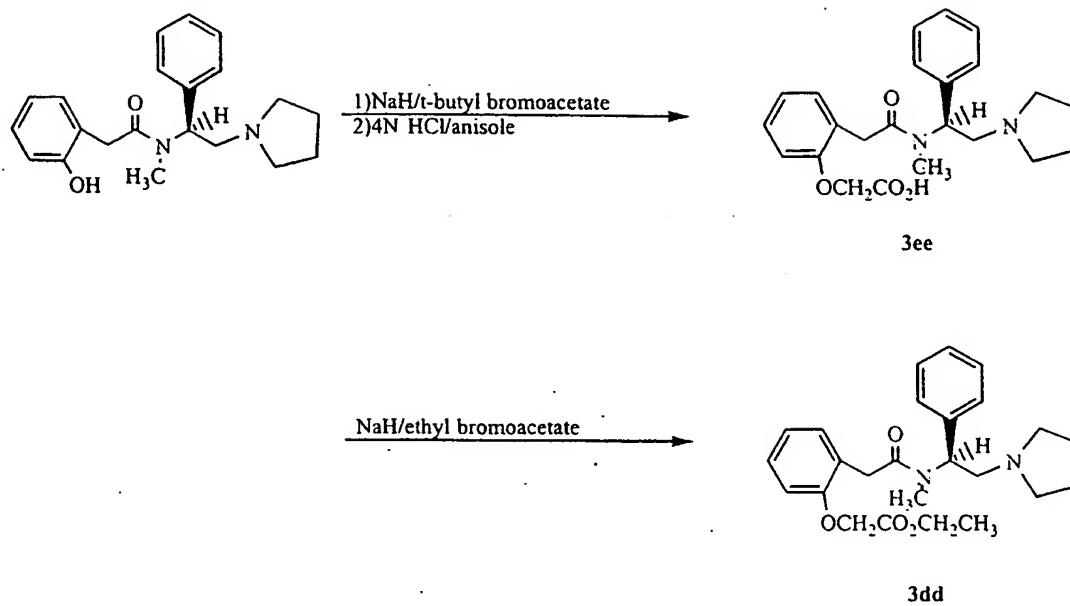
**Scheme I**

## Scheme J



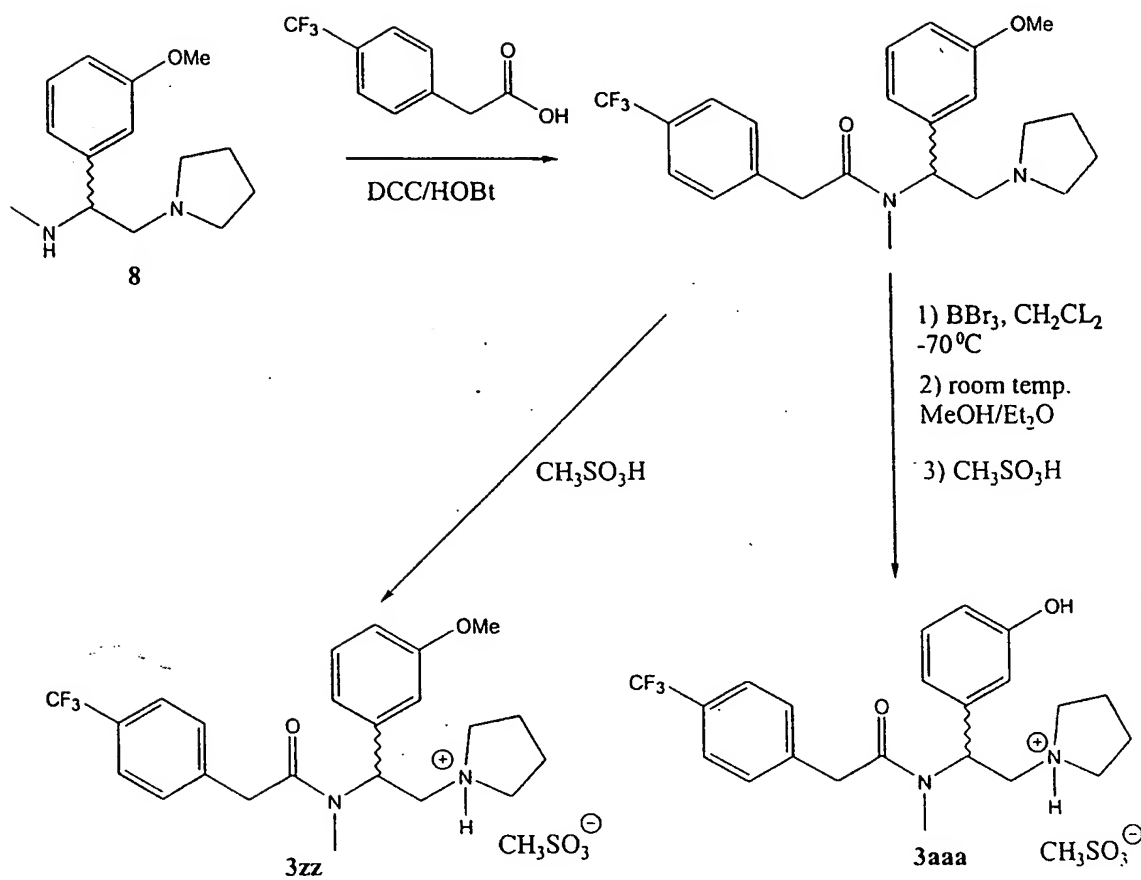
## Scheme K



Scheme L





**Scheme N**

5

**Example (3a)****2-(2-N-Methylsulfonamido-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride**

- 2-(N,N-Dimethylsulfonamido-2-amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide (for preparation see USP 5,688,955) 130 mg; 0.22 mmol was treated with 0.2 mL of 10 M NaOH in 3.0 mL of 2:1 MeOH:THF as described in the preparation of 3rr. The crude product was purified by flash chromatography using a stepwise gradient of 2% to 4% MeOH:methylene chloride with 2% ammonia to give 100 mg (95%) of desired product which was treated with 1.0 M HCl to afford 3a as a tan solid. Mp 140-142°C;
- 1H NMR (HCl salt, DMSO- $d_6$ )  $\delta$  2.0(br s, 4H,  $-\text{CH}_2\text{CH}_2-$ ), 2.8(s, 3H, NCH<sub>3</sub>), 3.1(s, 3H, SO<sub>2</sub>CH<sub>3</sub>), 3.6-3.8(m, 2H), 4.0-4.3(q, 2H), 6.0-6.2(dd, 1H), 7.2-7.6(complex, 5H, aromatic), 7.7-7.9(d, 2H), 9.5(s, NH). MS(FAB) m/z 483. Anal. (C, H, N) Calcd. for

$C_{22}H_{29}N_3O_3Cl_2SHCl \cdot 0.25 H_2O$ : C, 50.73; H, 5.42; N, 8.07. Found: C, 49.32; H, 5.52; N, 7.58.

### Example (3b)

#### 5 N-[(4-Trifluoromethylphenyl)-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl)ethyl]acetamidol glycine hydrochloride

To a stirred solution of bromoacetic acid (0.75 g, 5.42 mmol) in anhydrous  $CH_3CN$  (20 mL) was added N,N-diisopropylethylamine (1.41 g, 11.0 mmol) under a nitrogen atmosphere. After addition of 2-(2-Amino-4-trifluoromethylphenyl)-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl)ethyl]acetamide<sup>1</sup> (2.0 g, 4.93 mmol) in anhydrous  $CH_3CN$  (10 mL) to the  
10 reaction mixture, it was heated to 70°C for 6 days. TLC [solvent system:  $CH_2Cl_2$ :  $CH_3OH$ : 28%  $NH_4OH$  (95:5:2)] of the reaction mixture showed that still some starting material was present. The reaction mixture was cooled to room temperature and solvent was evaporated to dryness. The residue was partitioned between  $CH_2Cl_2$  and water, organic layer was separated,  
15 dried over anhydrous  $Na_2SO_4$ , and evaporated to dryness to give the crude mixture. The residue was crystallized from acetone and acetonitrile (1:1) to give the desired compound as a white solid 0.6 g which was still contaminated with minor amounts of the starting material.

The product **3b** was finally purified on Chromatotron (precoated silica plate) using solvent acetone:water (9:1) and recrystallized from acetonitrile to give the product as a white solid,  
20 0.35 g (15%); mp 228-230°C (d); MS (FAB) 464 (M+1);  $^1H$  NMR (200 MHz,  $DMSO-d_6$ )  $\delta$  2.16 (m, 4H), 2.88 (s, 3H), 3.47-4.00 (m, 9H), 4.50 (m, 1H), 4.95 (m, 1H), 6.34 (d, J = 9.0 Hz, 1H), 6.82 (d, J = 8.0 Hz, 1H), 7.02 (s, 1H), 7.18 (d, J = 7.7 Hz, 1H), 7.55 (m, 5H). Anal. Calcd. for  $C_{24}H_{28}F_3N_3O_3 \cdot 0.25H_2O$ : C, 61.59; H, 6.14; N, 8.98. Found: C, 61.54; H, 6.10; N, 9.36.

#### 25 Ref.

1. U. S. Patent, 5,688,955 (1997).

### Example 3c

#### 30 2-(3,4-Dichlorophenyl)-N-methyl-N-[(1R, S)-1-(3-sulfamidophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride

A solution of compound **1**<sup>1</sup> (203 mg, 0.5 mmol) and sulfamide (480 mg, 5 mmol) in dioxane (15 ml) was refluxed for 4 hours in oil bath. After removal of dioxane, the residue was partitioned between NaOH (1N, 50 ml) and  $CHCl_3$  (50 ml). The aqueous layer was extracted with  $CHCl_3$  (2x25 ml), and the combined extract was washed with brine, dried ( $Na_2SO_4$ ).  
35 Silica column chromatography of crude material gave a pure product that was converted to hydrochloric acid salt with HCl/ether (164 mg, 64%). Mp: 198-200°C. Spectral data:  $^1H$  NMR ( $DMSO-d_6$ )  $\delta$  1.97 (m, 4H), 2.80 (s, 3H), 3.12 (m, 2H), 3.52-3.66 (m, 3H), 3.72 (d, J=16.5 Hz, 1H), 4.01-4.10 (m, 2H), 6.04 (d, J=11.0 Hz, 1H), 6.88 (d, J=7.6 Hz, 1H), 6.99 (s, 1H), 7.17 (m, 1H), 7.29 (m, 1H), 7.55 (d, J=4.5 Hz, 1H), 9.10 (s, 1H). Fab MS ( $MH^+$ ): 485.

Anal. Calcd For  $C_{21}H_{26}N_4O_3Cl_2S \cdot HCl$ : C, 48.33; H, 5.21; N, 10.74. Found: C, 48.31; H, 5.21; N, 10.59.

### Example 3d

#### 2-(4-Trifluoromethylphenyl)-N-methyl-N-([1S]-1-[3-[(methylsulfonyl)aminolphenyl]-2-[1-pyrrolidinyl]ethyl]acetamide hydrochloride

4-Trifluoromethylphenyl acetic acid was condensed with (1S)-1-[2-(methylamino)-2-(3-nitrophenyl)-ethyl]pyrrolidine following the methods described in the literature<sup>1</sup> to give the intermediate, 3-nitro-derivative in 95% yield, <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.68 (m, 4H), 2.35-3.30 (m, 6H), 2.71 (s, 3H), 3.85 (m, 2H), 6.20 (m, 1H), 7.49 (m, 7H), 8.10 (s, 1H). The nitro group was reduced again following the method described in literature (Raney Ni/hydrazine hydrate) to corresponding 3-amino derivative in nearly quantitative yield.

To a solution of the above 3-amino compound (2.9 g, 7.15 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (30 mL) was added triethyl amine (3.62 g, 35.76 mmol) and the reaction mixture was cooled to in an ice-bath. Methane sulfonyl chloride (2.46 g, 21.45 mmol) was added dropwise in 15 min and the ice-bath was removed. The reaction mixture was stirred at room temperature for 72 h. The reaction mixture was quenched with addition of water, organic layer was separated, washed with water, saturated NaHCO<sub>3</sub>, saturated salt solution, and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. Removal of solvent gave 3-N-(bis-methylsulfonamide) derivative as a foam which was used directly into the following reaction.

The above compound (4.0 g, 7.12 mmol) was dissolved in CH<sub>3</sub>OH:THF (2:1, 32 mL) and stirred at room temperature. Sodium hydroxide (10 M aqueous solution) (1.29 g, 32.26 mmol) was added and stirred at room temperature for 20 min [TLC, solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (95:5:2)]. Reaction mixture was neutralized with the addition of 1N HCl and evaporated to dryness under reduced pressure. The residue was redissolved in ethyl acetate, washed with saturated NaHCO<sub>3</sub>, saturated salt solution, and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. Removal of the solvent under reduced pressure gave a yellow foam which was purified on a silica gel column [solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (95:5:2)]. The hydrochloride salt was prepared from 1M ethereal HCl and recrystallized from 2-propano:ether (1:1) to give **3d** as a cream colored solid in 45% yield; mp 173-175°C; <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.65 (m, 4H), 2.30-3.15 (m, 6H), 2.67 (s, 3H), 2.86 (s, 3H), 3.80 (m, 2H), 6.05 (m, 1H), 7.00-7.25 (m, 4H), 7.35 (d, J = 8.2 Hz, 2H), 7.50 (d, J = 8.0 Hz, 2H). Anal. Calcd. for C<sub>23</sub>H<sub>28</sub>F<sub>3</sub>N<sub>3</sub>O<sub>3</sub>S·HCl·0.5H<sub>2</sub>O: C, 55.22; H, 5.72; N, 7.94. Found: C, 52.17; H, 5.61; N, 7.96.

### Example 3e

#### 2-(4-Methanesulfonylphenyl)-N-methyl-N-([1S]-1-[3-[(methylsulfonyl)aminolphenyl]-2-[1-pyrrolidinyl]ethyl]acetamide methanesulfonate

The compound was prepared from 4-methylsulfonylphenyl acetic acid following the procedure described for **3d**. The methane sulfonic acid salt was recrystallized from CH<sub>2</sub>Cl<sub>2</sub>:ether to give **3e** as a beige colored solid in 32% yield; mp 140-142°C; <sup>1</sup>H NMR (300

MHz, DMSO- $d_6$ )  $\delta$  2.00 (m, 4H), 2.40 (s, 3H), 2.78 (s, 3H), 2.97 (s, 3H), 3.20 (s, 3H), 3.40-4.10 (m, 6H), 3.94 (d,  $J = 5.5$  Hz, 2H), 6.10 (m, 1H), 7.00 (d,  $J = 5.8$  Hz, 1H), 7.15 (s, 1H), 7.20 (t,  $J = 6.0$  Hz, 1H), 7.35 (t,  $J = 5.5$  Hz, 1H), 7.50 (d,  $J = 12.5$  Hz, 2H), 7.85 (d,  $J = 12.0$  Hz, 2H). Anal. Calcd. for  $C_{23}H_{31}N_3O_5S_2 \cdot CH_3SO_3H \cdot 2.0H_2O$ : C, 46.06; H, 6.28; N, 6.71.

Found: C, 45.99; H, 6.03; N, 6.55.

### Example 3f

#### 2-(3,4-Dichlorophenyl)-N-methyl-N-[[1S]-1-[3-[(methylsulfonyl)amino]phenyl]-2-[1-pyrrolidinyl]ethyl]acetamide hydrochloride

2-(3,4-Dichlorophenyl)-N-methyl-N-[[1S]-1-[3-(bis-methylsulfonyl)amino]phenyl]-2-[1-pyrrolidinyl]ethyl}acetamide<sup>1</sup> (1.8 g, 3.2 mmol) was dissolved in  $CH_3OH$ :THF (2:1, 90 mL) and added 10 M NaOH solution (0.58 g, 14.5 mmol). The reaction was followed by TLC [solvent system:  $CH_2Cl_2$ :  $CH_3OH$ : 28%  $NH_4OH$  (95:5:2)] and worked up as described in case of 3d to give the crude product as a foam. The compound was purified on a silica gel column [solvent system:  $CH_2Cl_2$ :  $CH_3OH$ : 28%  $NH_4OH$  (95:5:2)] and the hydrochloride salt was prepared from 1M etherial HCl. Recrystallization of the salt from  $CH_2Cl_2$ :ether (1:1) gave 3f as a beige colored solid, 0.57 g (35%); mp 240-242°C. Anal. Calcd. for  $C_{22}H_{27}Cl_2N_3O_3S \cdot HCl \cdot 0.25H_2O$ : C, 50.29; H, 5.47; N, 8.00. Found: C, 50.63; H, 5.26; N, 7.66

### Example 3g

#### 2-(3,4-Dichlorophenyl)-N-methyl-N-[(1S)-1-[3-(diethyl phosphoryl)amino]phenyl]-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride

2-(3,4-Dichlorophenyl)-N-methyl-N-[[1S]-1-(3-aminophenyl)-2-[1-pyrrolidinyl]ethyl}-acetamide<sup>1</sup> (0.411 g, 1.011 mmol) was dissolved in anhydrous THF (8 mL) and cooled in an ice-bath under a nitrogen atmosphere. Diisopropylethylamine (1.06 mL, 6.07 mmol) was added followed diethyl chlorophosphate (0.58 mL, 4.045 mmol). The reaction mixture was stirred at room temperature for 48 h, quenched with the addition of water, and evaporated to dryness. The residue was partitioned between  $CH_2Cl_2$  and saturated  $NaHCO_3$  solution. The organic layer was separated, dried over anhydrous sodium sulphate, and evaporated under reduced pressure to give the crude product. The compound was purified on a silica gel column [solvent system:  $CH_2Cl_2$ :  $CH_3OH$ : 28%  $NH_4OH$  (99:1:2)] and converted to the hydrochloride salt from 1M etherial HCl to give 3g, 0.44 g (81%); mp 140-142°C; <sup>1</sup>H NMR (200 MHz, DMSO- $d_6$ )  $\delta$  1.18 (t,  $J = 8.0$  Hz, 3H), 1.95 (m, 4H), 2.77 (s, 3H), 3.00-4.20 (m, 12H), 6.05 (m, 1H), 6.75 (d,  $J = 8.0$  Hz, 1H), 6.88 (s, 1H), 7.00 (d,  $J = 7.5$  Hz, 1H), 7.25 (m, 2H), 7.53 (m, 2H), 8.05 (d,  $J = 8.6$  Hz, 1H). Anal. Calcd. for  $C_{25}H_{34}Cl_2N_3O_4P \cdot HCl \cdot 0.5H_2O$ : C, 51.07; H, 6.17; N, 7.15. Found: C, 50.91; H, 5.93; N, 6.97.

**Example 3h****2-(3,4-Dichlorophenyl)-N-methyl-N-[(1S)-1-[3-[(4-oxo-butenate)]aminophenyl]-2-(1-pyrrolidinyl)ethyl]acetamide**

5 2-(3,4-Dichlorophenyl)-N-methyl-N-[(1S)-1-(3-aminophenyl)-2-[1-pyrrolidinyl]ethyl]-acetamide<sup>1</sup> (0.0347 g, 0.855 mmol) was dissolved in anhydrous THF (8 mL) under a nitrogen atmosphere and added a solution of maleic anhydride (0.084 g, 0.855 mmol) in anhydrous THF (1 mL) at room temperature. The reaction mixture was stirred at this temperature for 24 h and the resulting solid was filtered, washed with THF and ether. The solid was dried under  
 10 vacuum to give **3h**, (0.274 g, 63%); mp 174-176°C; MS 504 (m/z); ; <sup>1</sup>H NMR (200 MHz, DMSO-d<sub>6</sub>) δ 1.79 (m, 4H), 2.72(s, 3H), 2.85-3.85 (m, 6H), 5.95 (m, 1H), 6.10 (m, 1H), 6.25 (m, 1H), 6.95 (d, J = 8.0 Hz, 1H), 7.28 (m, 2H), 7.55 (m, 4H). Anal. Calcd. for C<sub>25</sub>H<sub>27</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>4</sub>·0.25H<sub>2</sub>O: C, 59.00; H, 5.45; N, 8.26. Found: C, 58.69; H, 5.18; N, 8.01.

**Example 3i****2-(3,4-Dichlorophenyl)-N-methyl-N-[(1S)-1-[3-(3-((iso-butoxycarbonyl)-methyl)aminocarbonyl)propionamido]phenyl]-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride**

20 A solution of compound **1** (222 mg, 0.546 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (10 ml) at 0 °C was treated with succinic anhydride (82 mg, 0.819 mmol). The mixture was allowed to warm up to room temperature and stirred for 18 hours. The solvent was removed by rotary evaporation and the residue was recrystallized from ethyl acetate and hexane (249 mg, 89%).  
 25 A mixture of the above compound (246 mg, 0.486 mmol), 1-hydroxybenzotriazole monohydrate (98 mg, 0.729 mmol), and p-toluenesulfonic acid salt of 2-methylpropyl glycine (221 mg, 0.729 mmol) in THF (5 ml) was treated with Et<sub>3</sub>N (0.102 ml, 0.729 mmol), followed by dicyclohexylcarbodiimide (150 mg, 0.729 mmol) in THF (2 ml). The mixture was stirred at room temperature for 48 hours, cooled in ice bath, and filtered. The filtrate was  
 30 concentrated, dissolved in ethyl acetate, and the solution was washed with aqueous NaHCO<sub>3</sub> (saturated), water, brine, dried (Na<sub>2</sub>SO<sub>4</sub>). After concentration, the residue was allowed to pass through a silica column eluted with 2% MeOH in CH<sub>2</sub>Cl<sub>2</sub> (2% ammonia). 216 mg of the desired product was obtained (72%) and part of the product was converted to the hydrochloric acid salt (compound **3i**, 67 mg). Mp: 85 °C (decomposed). Spectral data: <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 0.86 (d, J=6.7 Hz, 6H), 1.84 (m, 1H), 1.97 (m, 4H), 2.40-2.50 (m, 4H), 2.77 (s, 3H), 3.14 (m, 1H), 3.47-3.70 (m, 3H), 3.75-3.83 (m, 5H), 3.98-4.14 (m, 2H), 6.06 (d, J=10.0 Hz, 1H), 6.93 (d, J=7.7 Hz, 1H), 7.30 (m, 2H), 7.50-7.57 (m, 4H), 8.37 (bs, 1H). Fab MS (MH<sup>+</sup>): 485. Anal. Calcd for C<sub>31</sub>H<sub>40</sub>N<sub>4</sub>O<sub>5</sub>·HCl·1.2 H<sub>2</sub>O: C, 54.94; H, 6.46; N, 8.27. Found: C, 54.94; H, 6.43; N, 8.28.  
 40

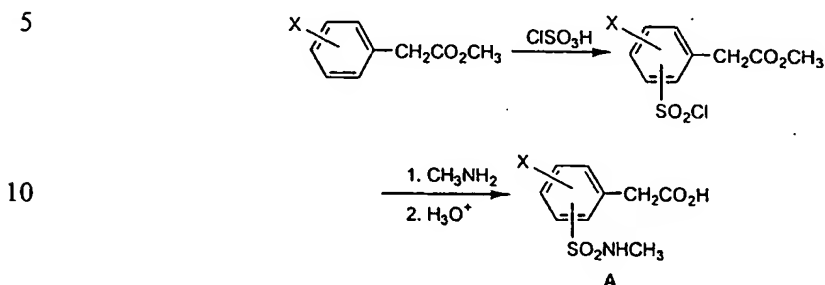
**Example 3j****2-(3,4-Dichlorophenyl)-N-methyl-N-[(1R, S)-1-[3-(3-(((hydroxycarbonyl)-methyl)aminocarbonyl)propionamido)phenyl]-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride**

- 5 A solution of compound 3i (144 mg, 0.233 mmol) in ethanol (3 ml) and water (1 ml) was cooled in ice bath and treated with NaOH (1N, 0.7 ml) slowly. After stirring at room temperature for 1 hour, the solution was adjusted to pH = 5 with 6N HCl. The mixture was stirred for 2 hours and then concentrated. The residue was separated by reversed phase TLC
- 10 plate to give the final product (114 mg, 80%). Mp: 158 °C (decomposed). Spectral data: <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 1.65 (bs, 4H), 2.40-2.64 (m, 4H), 2.70 (s, 3H), 3.11 (m, 2H), 3.33 (m, 2H), 3.71 (m, 3H), 3.86 (d, J=16.0 Hz, 1H), 5.81 (dd, J=9.9, 4.9 Hz, 1H), 6.94 (d, J= 8.1 Hz, 1H), 7.23 (t, J=7.8 Hz, 1H), 7.48-7.56 (m, 4H), 8.17 (bs, 1H), 9.95 (s, 1H). Fab MS (MH<sup>+</sup>): 563. Anal. Calcd for C<sub>27</sub>H<sub>32</sub>N<sub>4</sub>O<sub>5</sub>Cl<sub>2</sub>·HCl·0.75H<sub>2</sub>O: C, 52.79; H, 5.68; N, 9.12. Found: C, 52.83; H, 5.92; N, 9.10.
- 15

**EXAMPLE 3k****2-[(2-N-Phenylsulfonamido)-phenyl]-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamide methane sulfonate**

- 20 2-(2-Aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide (for preparation see USP 5,688,955) 1.2 g(3.55 mmol) was stirred in 30mL of dry CH<sub>2</sub>Cl<sub>2</sub> at 0°C. Triethylamine (0.5 mL; 3.55 mmol) and benzenesulfonyl chloride (0.45 mL; 3.55 mmol) in 10 mL of dry CH<sub>2</sub>Cl<sub>2</sub> were added. After the addition the reaction solution was allowed to
- 25 warm to room temperature and stirred overnight. TLC (90:10 methylene chloride : methanol w/2% ammonia) indicated the reaction was incomplete. 0.22 mL (1.7 mmol) of the chloride and 0.25 mL (1.7 mmol) of the base were added at 0°C. The solution was stirred for 24 h at room temperature before it was complete. The reaction was quenched with sat. sodium bicarbonate and the layers were separated. The organic layer was washed with brine, dried
- 30 (Na<sub>2</sub>SO<sub>4</sub>), filtered and concentrated *in vacuo* to give 1.9 g of crude product which was purified by flash chromatography using a stepwise gradient of 2% to 7% MeOH: methylene chloride w /2% ammonia to yield 1.2g of bis-alkylated product which was hydrolyzed using the same preparation as 3rr to afford 900 mg (53%) of desired product which was treated with 1.0 eq. of methanesulfonic acid to give 3k as a tan solid. mp 205-207°C; <sup>1</sup>H NMR (mesylate salt, CDCl<sub>3</sub>) δ 1.8(br m, 1H), 2.1(br d, 2H), 2.2(br t, 2H), 2.8(s, 3H, NCH<sub>3</sub>), 3.1(t, 1H), 4.0-4.3(d, 2H), 6.2(dd, 1H), 7.0(d, 2H), 7.1(m, 2H), 7.30 (complex, 5H, aromatic), 7.4(d, 1H), 7.5(d, 1H), 7.9(d, 2H), 9.0(s, 1H), 10.3(br, NH). MS(FAB) m/z 477. Anal. (C<sub>27</sub>H<sub>31</sub>N<sub>3</sub>O<sub>5</sub>S CH<sub>3</sub>SO<sub>3</sub>H: C, 58.62; H, 6.15; N, 7.32. Found: C, 58.66; H, 6.20; N, 7.27.
- 35

**General procedure for the preparation of N-methyl sulfamoyl derivatives of phenyl acetic acids**



15

To a stirred ice-cold chlorosulfonic acid (43.82 g, 0.376 mol) under anhydrous condition was added dropwise methyl phenylacetate (6.23 g, 0.042 mol). When addition was completed, the reaction mixture was then stirred at room temperature and the progress of the reaction was monitored by TLC [solvent: hexane :ethyl acetate (4:1)] [In this case the reaction was over in 30 min and however depending upon the substitution (X = H) of the aromatic ring, reaction may take from 12 to 72 h at room temperature]. Reaction mixture was then carefully poured on ice-water and the product was extracted with ether several times. The combined ethereal solution was washed with water, saturated salt solution, and dried over anhydrous sodium sulfate. Removal of ether under reduced pressure resulted in a mixture of 2- and 4-chlorosulfonyl compounds (63-85% yields) (chlorosulfonation was also depended upon the directing effects of the X group) which were used directly into next reaction.

To a stirred solution of methyl amine (19.5 ml, 2 M in THF, 0.039 mol) at 0°C under a nitrogen atmosphere was added a solution of above chlorosulfonyl derivative (3.25 g, 0.013 mo) in anhydrous THF (10 mL). Reaction mixture was stirred 15 min at this temperature and 1-4 h at room temperature by this time TLC [solvent: hexane :ethyl acetate (4:1)] showed no starting material was present. The solvent was removed under reduced pressure and the residue was partitioned between ethyl acetate and water. The organic layer was separated, washed with saturated salt solution, dried over anhydrous sodium sulfate, and evaporated to dryness to give methyl sulfonamide derivative (90-96% yield). In most cases this product was pure enough to proceed to next step, otherwise purified on a silica gel column before the hydrolysis of the ester.

The methyl sulfonamide ester (3.0 g, 12.34 mmol) was suspended in 3N aqueous HCl and heated to reflux with stirring for 24 h. The solvent was removed under reduced pressure and the residue was re-dissolved in CH<sub>2</sub>Cl<sub>2</sub>, filtered, and concentrated to a small volume. Addition of either ether or hexane gave compound A in 80-95% yield and these acids were used in the condensation reactions.

45



**Example 3l****2-[3-(N-Methylsulfamoyl)-4-chlorophenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl]acetamide hydrochloride**

- 5 To a solution of 3-(N-methylsulfamoyl)-4-chlorophenyl acetic acid (prepared from 4-chlorophenyl acetic acid, 1.58 g, 6.0 mmol) in anhydrous  $\text{CH}_2\text{Cl}_2$  (20 mL) under a nitrogen atmosphere was added N-hydroxybenzotriazole (0.81 g, 6.0 mmol). Reaction mixture was stirred at room temperature for 15 min then cooled in an ice-bath and added 1-(3-diethylaminopropyl)-3-ethylcarbodiimide hydrochloride (1.165 g, 6.0 mmol). Stirring was continued at ice-bath temperature for 30 min then added a solution of (1S) 1-[(2-methylamino-2-phenyl)ethyl]pyrrolidine<sup>1</sup> (1.02 g, 5.0 mmol) in anhydrous  $\text{CH}_2\text{Cl}_2$  (10 mL) followed by N,N-diisopropylethylamine (0.79 g, 6.1 mmol). Reaction mixture was continued stirring for 48h [TLC, solvent system:  $\text{CH}_2\text{Cl}_2$ :  $\text{CH}_3\text{OH}$ : 28%  $\text{NH}_4\text{OH}$  (95:5:2)]. After addition of more  $\text{CH}_2\text{Cl}_2$ , the organic phase was washed with water, saturated sodium bicarbonate solution, saturated salt solution, and dried over anhydrous sodium sulfate.
- 15 Removal of the solvent under reduced pressure gave the crude product which was converted to the hydrochloride salt from 1M ethereal HCl. The salt was re-crystallized from 2-propanol to give **3l** as off-white solid, 1.52 g (62%); 285-287°C; <sup>1</sup>H NMR (300 MHz,  $\text{DMSO}-d_6$ )  $\delta$  2.01 (m, 4H), 2.50 (d, J = 4.5 Hz, 3H), 2.87 (s, 3H), 3.17(m, 2H), 3.64 (m, 3H), 3.90 (d, J = 10.0Hz, 1H), 4.14 (d, J = 10.5 Hz, 2H), 6.20 (m, 1H), 7.28-7.45 (m, 4H), 7.55-7.65 (m, 3H), 7.90 (d, J = 3.5 Hz, 1H). Anal. Calcd. for  $\text{C}_{22}\text{H}_{28}\text{ClN}_3\text{O}_3\text{S}\cdot\text{HCl}\cdot 0.75\text{H}_2\text{O}$ : C, 52.85; H, 6.15; N, 8.40. Found: C, 52.84; H, 5.89; N, 8.40.

**Example 3m**

25 **2-(3-Sulfamoyl-4-chlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl]acetamide methanesulfonate**

- Prepared from 3-sulfonamido-4-chlorophenyl acetic acid following the above procedure and the free base was converted to methanesulfonic acid salt. Recrystallization from 2-propanol gave **3m** as a white solid in 51% yield; mp 220-222°C; MS (FAB) 436 (M+1); <sup>1</sup>H NMR (300 MHz,  $\text{DMSO}-d_6$ )  $\delta$  2.00 (m, 4H), 2.36 (s, 3H), 2.76 (s, 3H), 3.20 (m, 2H), 3.50-3.80 (m, 4H), 3.94 (bs, 2H), 6.15 (m, 1H), 7.25 (d, J = 6.0 Hz, 1H), 7.30-7.65 (m, 6H), 7.88 (d, J = 2.5 Hz, 1H). Anal. Calcd. for  $\text{C}_{21}\text{H}_{26}\text{ClN}_3\text{O}_3\text{S}\cdot\text{CH}_3\text{SO}_3\text{H}$ : C, 49.66; H, 5.68; N, 7.90. Found: C, 49.69; H, 5.63; N, 7.78.

**Example 3n**

35 **2-(3-Sulfamoyl-4-chlorophenyl)-N-methyl-N-[(1S)-1-[3-[(methylsulfonyl)amino]phenyl]-2-[1-pyrrolidinyl]ethyl]acetamide methanesulfonate**

- (S)-1-[2-(Methylamino)-2-(3-nitrophenyl)ethyl]pyrrolidine<sup>1</sup> was condensed with 3-sulfonamido-4-chlorophenyl acetic acid following the general procedure described in 83% yield. The catalytic reduction of the 3-nitro group was done with  $\text{PtO}_2$  to give the 3-amino intermediate. Bis-mesylation of the 3-amino group followed by selective removal one of the mesyl group as described for **3d** resulted in the desired compound in 28% yield.
- 40 Methanesulfonic acid salt was prepared in 71% yield to give **3n**; mp 170-173°C; MS (FAB)

543 (M+1); <sup>1</sup>H NMR (300 MHz, DMSO-d<sub>6</sub>) δ 1.98 (m, 4H), 2.35 (s, 3H), 2.44 (d, J = 5.0 Hz, 3H), 2.77 (s, 3H), 2.98 (s, 3H), 3.10-4.15 (m, 6H), 3.90 (d, J = 8.0 Hz, 2H), 6.20 (m, 1H), 7.00-7.75 (m, 6H), 7.90 (d, J = 2.0 Hz, 1H). Anal. Calcd. for C<sub>23</sub>H<sub>31</sub>ClN<sub>4</sub>O<sub>5</sub>S<sub>2</sub>·CH<sub>3</sub>SO<sub>3</sub>H·0.5H<sub>2</sub>O: C, 44.47; H, 5.60; N, 8.64. Found: C, 44.26; H, 5.53; N, 8.45.

#### Example 3o

##### 2-[3-(N-Methylsulfamoyl)-4-fluorophenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl]acetamide hydrochloride

Prepared from 3-methylsulfonamido-4-fluorophenyl acetic acid following the above procedure to give **3o** as a white solid in 85% yield; mp 278-280°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>) δ 1.73 (m, 4H), 2.61 (bs, 3H), 2.68 (s, 3H), 2.90-3.20 (m, 2H), 3.55-3.90 (m, 3H), 4.75 (b, 1H), 6.05 (m, 1H), 7.05-7.60 (m, 7H), 7.72 (bd, 1H). Anal. Calcd. for C<sub>22</sub>H<sub>28</sub>FN<sub>3</sub>O<sub>3</sub>S·HCl: C, 56.22; H, 6.22; N, 8.94. Found: C, 56.22; H, 6.24; N, 8.86.

#### Example 3p and 3r

##### 2-[2&4-(N-Methylsulfamoyl)-phenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl]acetamide hydrochloride

Compounds **3p** and **3r** were prepared using the general EDCI/DIPEA coupling procedure of (1S)-N-methyl-2-pyrrolidino-1-phenethylamine (1.3 g; 6.34 mmol), a mixture of 2 and 4 substituted reversed sulfamides acids (1.6 g; 6.98 mmol), HOBT (943 mg; 6.9 mmol), EDCI (1.33 g; 6.98 mmol) and DIPEA (1.32 mL; 7.60 mmol). After 24 hours, TLC (95:5 methylene chloride: methanol with 2% ammonia) indicates the reaction is complete. After the standard work-up, the crude product was purified using a stepwise gradient of 2% to 10% MeOH: methylene chloride with 2% ammonia to afford 1.6 g of a mixture of the 2 and 4 substituted sulfamide products. The mixture was separated using a stepwise gradient of 1% to 2% MeOH: methylene chloride with 2% ammonia on a chromatotran to afford 14 mg (0.5%) of the 2-substituted compound **3p** and 20 mg (0.7%) of the 4-substituted compound **3r**, which were converted to the HCl salt with 1.0 M HCl in diethyl ether. <sup>1</sup>H NMR (HCl salt, CDCl<sub>3</sub>) δ 1.7(br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.4-2.6(m, 2H), 2.6(d, 3H, NHCH<sub>3</sub>), 2.8(s, 3H, NCH<sub>3</sub>), 3.0-3.3(t, 2H), 3.8(d, 2H), 6.0-6.2(dd, 1H), 7.2-7.4(complex, 5H, aromatic), 7.5-7.7(m, 2H), 7.8(s, 2H). MS(FAB) m/z 415.

#### Example 3q

##### 3-(N-Methylsulfamoyl)-phenyl-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride

Compound **3q** was prepared using the HOBT/EDCI coupling procedure described in USP 5,885,955 with 3-SO<sub>2</sub>NHCH<sub>3</sub> phenyl acetic acid (A) 2.23 g; 9.73 mmol, (1S)-N-methyl-2-pyrrolidino-1-phenethylamine(1.90 g; 9.26 mmol), HOBT (1.31 g; 9.73 mmol), EDCI (1.85 g; 9.73 mmol) and DIPEA (3.38 mL; 19.46 mmol). The crude product was purified by flash chromatography using a stepwise gradient of 2% to 8% MeOH: methylene chloride with 2% ammonia to give 1.40 g (40%) of desired product which was treated with 1.0 M HCl in diethyl ether to afford **3q** as the HCl salt. mp >250°C(dec.); <sup>1</sup>H NMR (HCl salt, CDCl<sub>3</sub> with 3

drops of CD<sub>3</sub>OD)  $\delta$  2.0-2.2(br, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.6(s, 3H, NHCH<sub>3</sub>), 2.8(s, 3H, NCH<sub>3</sub>), 3.4-3.5(d, 2H), 6.3-6.4(dd, 1H), 7.2(d, 2H), 7.3-7.4(complex, 5H, aromatic), 7.5(t, 1H), 7.6(d, 1H), 7.7(d, 1H), 7.8(s, 1H). MS(FAB) m/z 415. Anal. (C,H,N) Calcd. for C<sub>22</sub>H<sub>29</sub>N<sub>3</sub>O<sub>3</sub>SHCl: C, 58.46; H, 6.69; N, 9.30. Found C, 59.34; H, 6.62; N, 9.19.

### Example 3s

#### 2-[N-Methylsulfamoyl]-4-bromo-phenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl acetamide hydrochloride

- Compound 3s was prepared using the HOBt/EDCI coupling procedure described in USP 5,885,955 using 2-SO<sub>2</sub>NHCH<sub>3</sub>, 4-bromophenyl acetic acid (2.3g;7.40mmol), (1S)-N-methyl-2-pyrrolidino-1-phenethylamine (1.4 g;7.08 mmol), HOBt (1.0 g;7.46 mmol), EDCI (1.4 g;7.46 mmol) and DIPEA (1.5 mL; 8.95 mmol). The crude product was purified by flash chromatography using a stepwise gradient of 2% to 8% MeOH: methylene chloride with 2% ammonia to give 500 mg (30%) of 3s as the desired product which was treated with 1.0 M HCl in diethyl ether to afford the HCl salt. mp >280°C; MS(FAB) m/z 494. Anal. (C,H,N) Calcd. for C<sub>22</sub>H<sub>28</sub>N<sub>3</sub>O<sub>3</sub>S Br HCl 0.5 H<sub>2</sub>O: C, 49.77; H, 5.51; N, 7.91. Found: C, 48.86; H, 5.36; N, 7.67.

### Example 3t

#### 2-[2&4-(N-Methylsulfamoyl)phenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-(3S)-3-hydroxypyrrolidinyl]ethyl]acetamide hydrochloride

- Prepared from A (X = H) and (1S) 1-[(2-methylamino-2-phenyl)ethyl](3S)-3-hydroxypyrrolidine<sup>1</sup> as a non-separable mixture of 2- and 4-substituted methylsulfonamido compound 3t in 16% yield; mp 1448-150°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>)  $\delta$  1.73 (m, 2H), 2.52 (bs, 3H), 2.66 (s, 3H), 2.10-3.40 (m, 6H), 3.76-3.81 (m, 3H), 4.20 (m, 1H), 6.00 (m, 1H), 7.15-7.55 (m, 8H), 7.70-7.82 (bd, 2H). Anal. Calcd. for C<sub>22</sub>H<sub>29</sub>N<sub>3</sub>O<sub>4</sub>.HCl: C, 55.92; H, 6.51; N, 8.89. Found: C, 55.90; H, 6.03; N, 8.49.

### Example 3u

#### 2-[2-Methoxy-3-(N-methylsulfamoyl)phenyl]-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride

- The compound 3u was prepared in 49% yield from 2-methoxy-3-(N-methylsulfamoyl)phenyl acetic acid following the general procedure; mp 278-280°C; <sup>1</sup>H NMR (free base, 200 MHz, CDCl<sub>3</sub>)  $\delta$  1.77 (m, 4H), 2.48 (d, J = 5.2 Hz, 3H), 2.82 (s, 3H), 2.50-3.90 (m, 6H), 3.67 (d, J = 10.5 Hz, 1H), 3.87 (s, 3H), 3.92 (d, J = 11.0 Hz, 1H), 4.75 (m, 1H), 6.05 (m, 1H), 6.95 (d, J = 8.5 Hz, 1H), 7.22-7.37 (m, 5H), 7.71-7.75 (m, 2H). Anal. Calcd. for C<sub>23</sub>H<sub>31</sub>N<sub>3</sub>O<sub>4</sub>S.HCl: C, 57.31; H, 6.69; N, 8.72. Found: C, 57.47; H, 6.64; N, 8.73.

Example 3v(Z)-4-[2-(2-Aminophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-(3S)-3-hydroxypyrrolidinyl]-ethyl]acetamido]4-oxo-2-butenic acid

- 5 To a solution of N-methyl-N-[(1S)-1-phenyl-2-((3S)-3-hydroxypyrrolidine-1-yl)ethyl]-2-aminophenylacetamide<sup>2</sup> (0.5 g, 1.42 mmol) in anhydrous THF (5 mL) under a nitrogen atmosphere was added maleic anhydride (0.139 g, 1.42 mmol) at room temperature for 48 h. The resulting dark solution was diluted with anhydrous ether. The resulting solid was filtered, washed thoroughly with ether, and dried to give 3v (0.55 g, 87%); mp 172-174°C (d); <sup>1</sup>H
- 10 NMR (200 MHz, DMSO-d<sub>6</sub>) δ 2.00-2.25 (m, 3H), 2.85 (s, 3H), 3.25-4.30 (m, 8H), 4.50 (m, 1H), 5.95 (d, J = 12.5 Hz, 1H), 6.20 (m, 1H), 6.35 (d, J = 12.8 Hz, 1H), 7.15-7.67 (m, 8H), 7.80 (d, J = 6.5 Hz, 1H). Anal. Calcd. for C<sub>25</sub>H<sub>29</sub>N<sub>3</sub>O<sub>5</sub>·0.75H<sub>2</sub>O: C, 64.57; H, 6.61; N, 9.04. Found: C, 64.33; H, 6.40; N, 8.83.

Ref.

- 15 2. Gottschlich R. et. Al. BioOrg. Med. Chem. Lett., 4, 677-682 (1994)

Example 3w(Z)-4-[2-(2-Amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]ethyl]acetamido]4-oxo-butanoic acid

- 20 To a solution of 2-(2-Amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)-ethyl]acetamide<sup>1</sup> (0.86 g, 2.0 mmol) in anhydrous THF under a nitrogen atmosphere was added succinic anhydride (0.25 g, 2.5 mmol). The reaction mixture was stirred at room temperature for 96 h and added excess of anhydrous ether. The resulting solid was filtered off, washed with ether and dried to give crude product. The compound was
- 25 purified on a silica gel column (acetone:water, 9:1). The desired compound was re-dissolved in CH<sub>2</sub>Cl<sub>2</sub>, filtered, and concentrated to a small volume. Addition of ether resulted the solid which was filtered, washed with ether, and dried to give 3w (0.32 g, 30%); mp 168-170°C; <sup>1</sup>H
- 30 NMR (300 MHz, CDCl<sub>3</sub>) δ 2.03 (m, 4H), 2.36 (m, 1H), 2.66 (m, 2H), 2.81 (s, 3H), 2.80-2.95 (m, 2H), 3.10 (m, 1H), 3.40 (d, J = 14.0 Hz, 1H), 3.67 (d, J = 14.5 Hz, 1H), 4.18 (t, J = 12.0 Hz, 1H), 6.40 (d, J = 11.5 Hz, 1H), 7.20 (m, 3H), 7.45 (m, 3H), 8.00 (s, 1H). Anal. Calcd. for C<sub>25</sub>H<sub>29</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>4</sub>S<sub>2</sub>·0.5H<sub>2</sub>O: C, 58.26; H, 5.87; N, 8.15. Found: C, 58.08; H, 5.75; N, 7.96.

Example 3x(Z)-4-[2-(2-Amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]-ethyl]acetamido]4-oxo-2-butenic acid

- 35 To a solution of 2-(2-amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)-ethyl]acetamide<sup>1</sup> (0.8 g, 1.85 mmol) in anhydrous THF (10 mL) under a nitrogen atmosphere was added maleic anhydride (0.181 g, 1.85 mmol) and the stirred at room temperature for 4 days. After addition of anhydrous ether, the resulting solid was sonicated

and filtered. Recrystallization of the solid from  $\text{CH}_2\text{Cl}_2$ :ether (1:1) gave 3x (0.51 g, 52% yield); mp 158-160°C (d);  $^1\text{H}$  NMR (200, MHz,  $\text{CDCl}_3$ )  $\delta$  2.00 (m, 4H), 2.72 (s, 3H), 2.75-3.20 (m, 2H), 3.35 (d,  $J = 12.5$  Hz, 1H), 3.85 (d,  $J = 13.0$  Hz, 1H), 3.90-4.20 (m, 2H), 6.10 (d,  $J = 12.5$  Hz, 1H), 6.25 (m, 2H), 7.15 (m, 3H), 7.44 (m, 3H), 8.00 (s, 1H). Anal. Calcd. for  $\text{C}_{25}\text{H}_{27}\text{Cl}_2\text{N}_3\text{O}_4 \cdot 0.25\text{H}_2\text{O}$ : C, 59.00; H, 5.45; N, 8.26. Found: C, 59.20; H, 5.57; N, 7.90.

### Example 3y

#### (E) Ethyl 4-[2-(2-amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]ethyl]acetamido]4-oxo-2-butenate hydrochloride

To a solution of fumaric acid monoethyl ester (1.30 g, 9.02 mmol) in anhydrous  $\text{CH}_2\text{Cl}_2$  (20 mL) under anitrogen atmosphere was added DCC (1.86 g, 9.03 mmol) followed by pyridine (0.43 mL, 5.31 mmol). The reaction mixture was stirred at room temperature for 30 min then added a solution of 2-(2-amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-(1-pyrrolidinyl)-ethyl]acetamide<sup>1</sup> (2.30 g, 5.31 mmol) in anhydrous  $\text{CH}_2\text{Cl}_2$  (10 mL). The reaction mixture was stirred at this temperature for 72 h, filtered and evaporated to dryness to give the crude product. The compound was purified on asilica gel column [solvent system:  $\text{CH}_2\text{Cl}_2$ :  $\text{CH}_3\text{OH}$ : 28%  $\text{NH}_4\text{OH}$  (99:1:2)] to give the free base of the desired product. The hydrochloride salt was prepared from 1M etherial HCl and recrystallized from  $\text{CH}_2\text{Cl}_2$ :ether (1:1) to give 3y (2.0 g, 60%); mp 165-167°C (d);  $^1\text{H}$  NMR (300, MHz,  $\text{CDCl}_3$ )  $\delta$  1.28 (t,  $J = 7.0$  Hz, 3H), 2.00-2.40 (m, 4H), 2.89 (s, 3H), 2.96 (m, 2H), 3.28 (m, 1H), 3.50 (m, 2H), 3.95-4.10 (m, 4H), 4.21 (q,  $J = 7.1$  Hz, 2H), 4.50 (d,  $J = 15.0$  Hz, 1H), 6.33 (d,  $J = 10.0$  Hz, 1H), 6.89 (d,  $J = 15.0$  Hz, 1H), 7.10-7.40 (m, 5H), 7.93 (d,  $J = 15.3$  Hz, 1H), 8.43 (s, 1H). Anal. Calcd. for  $\text{C}_{27}\text{H}_{31}\text{Cl}_2\text{N}_3\text{O}_4 \cdot \text{HCl} \cdot \text{H}_2\text{O}$ : C, 55.25; H, 5.84; N, 7.16. Found: C, 55.63; H, 5.73; N, 6.94.

### Example 3z

#### (Z)-4-[2-(2-Amino-4-trifluoromethylphenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]-ethyl]acetamido]4-oxo-2-butenic acid

The compound 3z was prepared from 2-(2-amino-4-trifluoromethylphenyl)-N-methyl-N-[(1S)-1-phenyl]-2-(1-pyrrolidinyl)-ethyl]acetamide<sup>1</sup> following the above in 40% yield; mp 153-155°C (d); MS (FAB) 504 (M+1);  $^1\text{H}$  NMR (200, MHz,  $\text{DMSO}-d_6$ )  $\delta$  2.01 (m, 4H), 2.85 (s, 3H), 2.85-3.30 (m, 2H), 3.40 (d,  $J = 14.5$  Hz, 1H), 3.95 (d,  $J = 14.0$  Hz, 1H), 4.10 (m, 2H), 6.30 (m, 3H), 7.18 (m, 3H), 7.38 (m, 4H), 8.15 (s, 1H). Anal. Calcd. for  $\text{C}_{26}\text{H}_{28}\text{F}_3\text{N}_3\text{O}_4 \cdot 0.75\text{H}_2\text{O}$ : C, 60.40; H, 5.75; N, 8.13. Found: C, 60.07; H, 5.50; N, 7.91.

### Example 3aa

#### (Z)-4-[2-(2-Aminophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]-ethyl]acetamido]4-oxo-2-butenic acid hemimaleate

The compound 3aa was prepared from 2-(2-aminophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-(1-pyrrolidinyl)-ethyl]acetamide<sup>1</sup> following the above in 93% yield; mp 149-151°C; Anal.

Calcd. for  $C_{25}H_{29}N_3O_4 \cdot 0.5C_4H_4O_4 \cdot H_2O$ : C, 63.39; H, 6.50; N, 8.21. Found: C, 63.37; H, 6.20; N, 8.22.

### Example 3bb

#### 5     2-(N,N-Bisacetic acid-2-amino- $\alpha,\alpha,\alpha$ -trifluoro-4-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride

2-(2-Amino, $\alpha,\alpha,\alpha$ -trifluoro-4-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]-acetamide (for the preparation see USP 5,688,955) 2.0 g; 4.93 mmol was dissolved in 50ml of  
 10     dry THF at 0°C. DIPEA (5.15 mL; 29.6 mmol) and t-butyl bromoacetate (3.64 mL; 24.65 mmol) were added 15 minutes apart. The reaction was allowed to warm to room temperature and stirred for 4 days. TLC (95:5 methylene chloride: methanol with 2% ammonia) indicated the reaction is incomplete. Added 1.67mL (9.58 mmol) of DIPEA to the reaction. After 24 hours the reaction mixture was concentrated to a residue. The residue was dissolved in  
 15     methylene chloride and washed with sat. sodium bicarbonate and brine. The organic layer was dried (anh.  $Na_2SO_4$ ), filtered and concentrated *in vacuo* to give a yellow oil. The crude product was purified by flash chromatography using a stepwise gradient of 1% to 8% MeOH: methylene chloride with 2% ammonia to afford 1.2g (61%) of bis-alkylated material which was used in the next step [ $^1H$  NMR, (Free base,  $CDCl_3$ )  $\delta$  1.4 (s, 9H, t-butyl), 1.5(s, 9H, t-butyl), 1.7-1.9(m, 4H), 3.2(s, 3H,  $NCH_3$ ), 3.6-3.7(dd, 4H), 4.3-4.8(q, 4H), 5.7-5.9(dd, 1H), 6.0(d, 1H), 6.4(d, 1H), 6.6(s, 1H), 6.9-7.2(m, 2H), 7.4(complex, 3H, aromatic). MS(FAB) m/z 633. The bis-alkylated compound (1.2 g; 1.89 mmol) was stirred in 33mL of glacial acetic acid with 4 drops of anisole. After 60 hours, the reaction was concentrated *in vacuo*. The residue was dissolved in acetonitrile and added drop-wise to a solution of 1.0 M HCl in  
 25     diethyl ether. The precipitate was collected by filtration and dried at 40°C under vacuum to yield 960 mg (93%) of **3bb** as a tan solid. mp 166-169°C;  $^1H$  NMR (HCl salt,  $DMSO-d_6$ )  $\delta$  1.6(br s, 4H,  $-CH_2CH_2-$ ), 2.9(s, 3H,  $NCH_3$ ), 3.8(q, 4H, 4.1-4.3(d, 2H), 4.7-4.9(m, 3H), 6.6(br d, 1H), 7.1(s, 1H), 7.4(d, 1H), 7.6(d, 1H), 7.7-8.0(complex, 5H, aromatic). MS(FAB) m/z 521. Anal. (C,H,N) Calcd. for  $C_{26}H_{30}N_3O_3F_3 \cdot 2 HCl \cdot H_2O$ : C, 58.46; H, 6.69; N, 9.30. Found:  
 30     C, 58.40; H, 6.65; N, 9.21.

### Example 3cc

#### 35     3-[2-N-Methylsulfonamido)-phenyl]-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride

Compound 3cc was prepared using the same procedure as described in the preparation of compound (2-N-Methylsulfonylamido-2-aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide (for the preparation see USP 5,688,955). Compound 3-(N,N-Dimethylsulfonamido-2-aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide (1.0 g; 2.02 mmol), 10 mL of 10 M NaOH and 30 mL of 2:1 MeOH: THF. The crude product was clean by TLC and  $^1H$  NMR (760 mg; 90%). The product was treated with 1.0 M HCl in diethyl ether to give 3cc as the HCl salt; mp 155-160°C(dec.);  $^1H$  NMR (Free base,  $CDCl_3$ )  $\delta$  1.7(br s, 4H,  $-CH_2CH_2-$ ), 2.5(br d, 2H), 2.8(s, 3H,  $NCH_3$ ), 2.9(s, 3H,  $SO_2CH_3$ ), 3.7(d, 2H), 6.0-6.1(dd, 1H), 7.0-7.4(complex, 9H, aromatic). MS(FAB) m/z 415. Anal. (C,H,N) Calc. for  $C_{22}H_{29}N_3O_3S \cdot HCl$ : C, 58.46; H, 6.69; N, 9.30. Found: C, 58.40; H, 6.65; N, 9.21.

**Example 3dd****2-(O-Butylacetate)-phenyl-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl]acetamide hydrochloride**

5 2-(2-Hydroxyphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide (for preparation see USP 5,688,955,) 1.3 g;(3.80 mmol) was dissolved in 10mL of dry THF and added to a 0°C slurry of NaH (95%, 100mg; 4.03 mmol) in dry THF. The mixture was allowed to warm to room temperature for 30 minutes, then cooled to 0°C. Ethyl bromoacetate  
10 (0.44 mL; 4.03 mmol) was added drop-wise over a few minutes. After 30 minutes, the mixture was warmed to room temperature and stirred for 5 days. TLC(95:5 methylene chloride: methanol with 2% ammonia) indicated the reaction was complete. The reaction was quenched with sat. ammonium chloride and concentrated *in vacuo*. The residue was dissolved in methylene chloride and separated from water. The organic layer was washed with brine,  
15 dried (anh. Na<sub>2</sub>SO<sub>4</sub>), filtered and concentrated *in vacuo* to give 1.61 g of crude product, which was purified by flash chromatography using a stepwise gradient of 2% to 9% MeOH: methylene chloride with 2% ammonia to afford 1.0 g (70%) of 3dd as a desired product, which was treated with 1.0 M HCl in diethyl ether to give the HCl salt. mp 184-187°C; <sup>1</sup>H NMR (HCl salt, CDCl<sub>3</sub>) δ 1.2(t, 3H), 1.7-1.9(br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.0(br d, 2H), 2.2-2.5(m, 2H), 2.8-3.0(m, 2H), 3.0(s, 3H, NCH<sub>3</sub>), 3.3-3.5(t, 1H), 4.0-4.1(m, 2H), 4.2(q, 2H), 6.2-6.3(dd, 1H), 6.8(d, 1H), 6.9-7.1(t, 1H), 7.2-7.5(complex, 7H, aromatic). MS(FAB) m/z 424. Anal. (C<sub>25</sub>H<sub>32</sub>N<sub>2</sub>O<sub>4</sub>·HCl 0.5 H<sub>2</sub>O: C, 65.14; H, 7.22; N, 6.08. Found: C, 63.70; H, 7.00; N, 6.09.

25

**Example 3ee****2-[Phenoxy-acetyl]methylamino-(1-pyrrolidinyl)ethyl]acetamide]hydrochloride**

2-(2-Hydroxyphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide (for the preparation see USP 5,688,955) 960 mg; 2.83 mmol was dissolved in 6.0 mL of dry THF and  
30 added to a slurry of NaH (95%) 79 mg; 3.12 mmol in dry THF at 0°C. The mixture was allowed to warm to room temperature and stirred for 30 minutes, then cooled to 0°C when t-butyl bromoacetate (0.42 ml; 2.83 mmol) in 2 mL of dry THF was added drop-wise. The solution was allowed to warm to room temperature and stirred overnight. TLC (95:5 methylene chloride: methanol w/ 2% ammonia) indicated the reaction was complete. The  
35 reaction was quenched with saturated ammonium chloride and concentrated *in vacuo*. The residue was dissolved in methylene chloride and separated from water. The organic layer was washed with brine, dried (anh. Na<sub>2</sub>SO<sub>4</sub>), filtered, and evaporated to give a brown residue. The crude product was purified by flash chromatography using a stepwise gradient of 1% to 8% MeOH: methylene chloride with 2% ammonia to afford 900 mg (70%) of desired compound;  
40 <sup>1</sup>H NMR, (Free base, CDCl<sub>3</sub>) δ 1.4(s, 9H, t-butyl), 2.7-2.9(br s, 4H), 2.7(s, 3H), 3.8(s, 2H), 4.5(s, 2H), 6.1-6.2(dd, 1H), 6.7-6.8(d, 2H), 6.9-7.0(t, 3H), 7.1-7.4 (complex, 5H, aromatic), MS(FAB) m/z 452] which was used in the next step by adding 4.0 mL of 4N HCl, 4 drops of anisole and stirring overnight at room temperature. TLC indicated the reaction was incomplete. The solution was heated to 50°C for 24 hours. The reaction mixture was  
45 concentrated *in vacuo* and the residue was azeotroped with toluene. The crude product was dissolved in triturated with diethyl ether to give 730 mg (93%) of 3ee as the free acid; mp 105-108°C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 1.9-2.4(br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.9(s, 3H,

NCH<sub>3</sub>)3.8-4.1(m, 3H), 4.5-4.7(d, 2H), 6.2(dd, 1H), 6.8(d, 1H), 6.9(t, 1H), 7.1-7.3(complex, 7H, aromatic). MS(FAB) m/z 396. Anal. (C,H,N) Calcd. for C<sub>23</sub>H<sub>23</sub>N<sub>2</sub>O<sub>4</sub>·HCl·0.75 H<sub>2</sub>O: C, 63.81; H, 6.75; N, 6.47. Found C, 61.87; H, 6.84; N, 6.19.

5

**Example 3ff****2-[4-Trifluoromethylphenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-(3S)-3-hydroxy-pyrrolidinyl]ethyl]acetamide hydrochloride**

The compound 3ff was prepared from N-methyl-N-[(1S)-1-phenyl-2-((3S)-3-hydroxypyrrolidine-1-yl)ethyl]-2-aminophenylacetamide<sup>2</sup> and 4-trifluoromethylphenyl acetic acid in 54 % yield; mp 217-219°C (d); <sup>1</sup>H NMR (free base, 200, MHz, CDCl<sub>3</sub>) δ 1.88 (m, 2H), 2.35 (m, 3H), 2.85 (s, 3H), 2.50-3.35 (m, 4H), 3.98 (m, 2H), 4.10 (m, 1H), 6.00 (m, 1H), 7.30 (m, 5H), 7.55 (d, J = 9.0 Hz, 2H), 7.77 (d, J = 9.5 Hz, 2H). Anal. Calcd. for C<sub>22</sub>H<sub>25</sub>F<sub>3</sub>N<sub>2</sub>O<sub>2</sub>·HCl: C, 59.66; H, 5.92; N, 6.32. Found: C, 59.45; H, 5.68; N, 5.98.

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**Example 3gg****2-(2-Pyridyl)-N-methyl-N-[(1S)-1-phenyl-2-[1-(3S)-3-hydroxy-pyrrolidinyl]ethyl]acetamide dihydrochloride**

The compound 3gg was prepared as above from 2-pyridyl acetic acid in 38% yield; mp 180-182°C (d); <sup>1</sup>H NMR (free base, 200, MHz, CDCl<sub>3</sub>) δ 1.78 (m, 2H), 2.10-2.65 (m, 3H), 2.75 (s, 3H), 2.88-3.20 (m, 4H), 3.95 (d, J = 13.0 Hz, 1H), 4.10 (d, J = 13.5 Hz, 1H), 4.20 (m, 1H), 6.05 (m, 1H), 7.20 (m, 7H), 7.60 (t, J = 7.0 Hz, 1H), 8.35 (d, J = 6.5 Hz, 1H). Anal. Calcd. for C<sub>20</sub>H<sub>25</sub>N<sub>3</sub>O<sub>2</sub>·2HCl·0.25H<sub>2</sub>O: C, 57.63; H, 6.65; N, 10.8. Found: C, 57.73; H, 6.79; N, 9.83.

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**Example 3hh****2-(5-Bromo-3-pyridyl)-N-methyl-N-[(1S)-1-phenyl-2-pyrrolidinyl ethyl]acetamide hydrochloride**

Compound 3hh was prepared using the general EDCI/DIPEA coupling procedure from USP 5,688,955 with, (1S)-N-methyl-2-pyrrolidino-1-phenethylamine (200 mg; 0.98 mmol), 5-bromo-3-pyridylacetic acid (231 mg; 1.07 mmol), HOBt (145 mg; 1.07 mmol), EDCI (204 mg; 1.07 mmol), and DIPEA (0.26 mL; 1.47 mmol). The reaction solution was allowed to stir at room temperature overnight. TLC (95:5 methylene chloride: methanol with 2% ammonia) indicated the reaction was complete. The reaction was quenched with sat. sodium bicarbonate and the layers were separated. The organic layer was washed with brine and dried (anh. Na<sub>2</sub>SO<sub>4</sub>), filtered and evaporated. The crude product was purified by flash chromatography using a stepwise gradient of 2% to 4% MeOH: methylene chloride with 2% ammonia to afford 337 mg (85%) of pure product which was treated with 1.0 M HCl in diethyl ether to give 3hh as the HCl salt; mp 228-230°C; <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 2.0 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.8 (s, 3H, NCH<sub>3</sub>), 4.1-4.2 (br m, CH<sub>2</sub>), 6.1-6.2 (br d, 1H, CH), 7.2-7.5 (complex, 5H, aromatic), 8.0-8.1 (br s, 1H, pyridyl), 8.5 (s, 1H, pyridyl), 8.6 (s, 1H, pyridyl); MS(FAB) m/z 401. Anal. (C,H,N) Calcd. for C<sub>20</sub>H<sub>24</sub>N<sub>3</sub>OBr·HCl: C, 54.75; H, 5.74; N, 9.58. Found: C, 54.66; H, 5.71; N, 9.41.

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**Example 3ii****2-(5-Bromo-3-pyridyl)-N-methyl-N-([1S]-1-phenyl-2-[1-(3S)-3-hydroxy-pyrrolidinyl]ethyl)acetamide hydrochloride**

- 5 The compound 3ii was prepared from 5-bromo-3-pyridyl acetic acid following the procedures described above in 44% yield; mp 144-146°C; <sup>1</sup>H NMR (free base, 200, MHz, CDCl<sub>3</sub>) δ 1.66 (m, 2H), 2.00-2.50 (m, 3H), 2.77(s, 3H), 2.88-3.40 (m, 4H), 3.80(d, J = 13.0 Hz, 1H), 3.95 (d, J = 13.5 Hz, 1H), 4.35 (m, 1H), 6.15 (m, 1H), 7.20 (m, 5H), 7.75 (s, 1H), 8.50 (s, 1H), 8.85 (s, 1H). Anal. Calcd. for C<sub>20</sub>H<sub>24</sub>BrN<sub>3</sub>O<sub>2</sub>.HCl.0.25H<sub>2</sub>O: C, 51.79; H, 5.65; N, 9.06. Found: C, 51.96; H, 5.55; N, 8.76.

**Example 3jj****2-(9-Anthracenyl)-N-methyl-N-([1S]-1-phenyl-2-(1-pyrrolidinyl)ethyl)acetamide hydrochloride**

- 15 The compound 3jj was prepared from 9-anthracene carboxylic acid as above in 34% yield; mp 273-275°C; <sup>1</sup>H NMR (200, MHz, CDCl<sub>3</sub>) δ 2.00 (m, 4H), 2.67 (s, 3H), 3.00 (m, 1H), 3.45 (m, 1H), 3.88 (m, 1H), 4.40 (m, 2H), 5.80 (m, 1H), 7.43 (m, 8H), 7.88 (m, 5H), 8.38 (s, 1H). Anal. Calcd. for C<sub>28</sub>H<sub>28</sub>N<sub>2</sub>O.HCl.0.25H<sub>2</sub>O: C, 74.82; H, 6.61; N, 6.23. Found: C, 75.00; H, 6.60; N, 6.26.

**Example 3kk****2-(2-Carboxyphenyl)-N-methyl-N-([1S]-1-phenyl-2-(1-pyrrolidinyl)ethyl)acetamide hydrochloride**

- To a solution of (S)-1-[(2-methylamino-2-phenyl)ethyl]pyrrolidine<sup>1</sup> (1.0 g, 5.21 mmol) in anhydrous THF (5 mL) under a nitrogen atmosphere was added homophthalic anhydride (0.845 g, 5.21 mmol) and the reaction mixture was stirred at room temperature for 4 days. The resulting solid was filtered, washed with THF and HCl salt was prepared by usual fashion to give 3kk (1.0 g, 50%); mp 230-232°C (d); MS (FAB) 367 (M+1); <sup>1</sup>H NMR (200, MHz, DMSO-d<sub>6</sub>) δ 2.07 (m, 4H), 2.92 (s, 3H), 3.30-3.98 (m, 5H), 4.00 (d, J = 14.0 Hz, 1H), 4.18 (m, 1H), 4.43 (d, J = 14.0 Hz, 1H), 6.15 (m, 1H), 7.30-7.65 (m, 8H), 8.00 (d, J = 8.0 Hz, 1H). Anal. Calcd. for C<sub>22</sub>H<sub>26</sub>N<sub>2</sub>O<sub>3</sub>.HCl: C, 65.58; H, 6.75; N, 6.96; Cl, 8.81. Found: C, 65.52; H, 6.81; N, 7.04; Cl, 8.81.

**Example 3ll****[2-(2-Phenyl)-N-methyl-N-([1S]-1-phenyl-2-(1-pyrrolidinyl)ethyl)acetamido]2-oxo-glycine hydrochloride**

- 35 To a suspension of 3ff was condensed with glycine t-butyl ester hydrochloride following the general procedure to give the intermediate in 55% yield. The t-butyl group was removed by 4N HCl to give the desired product which was recrystallized from acetonitrile to give 3ll in 93% yield; mp 235-236°C; MS (FAB) 424 (M+1); <sup>1</sup>H NMR (200, MHz, DMSO-d<sub>6</sub>) δ 1.95 (m, 4H), 2.72 (s, 3H), 3.35-4.25 (m, 11H), 6.18 (m, 1H), 7.20-7.65 (m, 8H), 8.70(m, 1H).

Anal. Calcd. for  $C_{24}H_{29}N_3O_4 \cdot HCl \cdot 0.75H_2O$ : C, 60.88; H, 6.71; N, 8.87. Found: C, 60.97; H, 6.65; N, 8.91.

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**Example 3mm****Methyl N-[2-(2-phenyl)-N-methyl-N-{[1S]-1-phenyl-2-(1-pyrrolidinyl)ethyl}acetamido]2-oxo-glycinate hydrochloride**

To a solution of **3ff** (0.50 g, 1.05 mmol) in anhydrous methanol (50 mL) was added Dowex<sup>®</sup> 50Wx4-400 ( $H^+$ ) resin (5.0 g, pre-washed with methanol). The reaction mixture was the stirred with refluxing under a nitrogen atmosphere for 48 h. The resin was removed by filtration washed with excess of hot methanol and the combined methanolic solution was evaporated to dryness. The residue was redissolved in  $CH_2Cl_2$  and concentrated to a small volume and addition of anhydrous ether resulted the compound **3mm** (0.12 g, 24%); mp 204-206°C; MS (FAB) 438 ( $M+1$ );  $^1H$  NMR (200, MHz,  $CDCl_3$ )  $\delta$  1.85-2.45 (m, 6H), 2.75-3.25 (m, 2H), 2.92 (s, 3H), 3.75 (s, 3H), 3.80-4.25 (m, 7H), 6.25 (bs, 1H), 7.15-7.77 (m, 9H). Anal. Calcd. for  $C_{25}H_{31}N_3O_4 \cdot HCl \cdot 0.25H_2O$ : C, 62.75; H, 6.85; N, 8.78. Found: C, 62.65; H, 6.87; N, 8.60.

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**Example 3nn****2-(3,4-Dihydroxyphenyl)-N-methyl-N-{[1S]-1-phenyl-2-(1-pyrrolidinyl)ethyl}acetamide hydrochloride**

The compound was prepared from 3,4-dihydroxyphenyl acetic acid in 12% yield; mp 227-229°C (d);  $^1H$  NMR (300, MHz,  $DMSO-d_6$ )  $\delta$  1.90 (m, 4H), 2.70 (s, 3H), 3.05-3.20 (m, 2H), 3.35 (bs, 2H), 3.45-3.70 (m, 4H), 4.50 (m, 1H), 6.12 (m, 1H), 6.45 (d,  $J = 8.1$  Hz, 1H), 6.62 (m, 2H), 7.18 (d,  $J = 7.5$  Hz, 2H), 7.32 (m, 3H), 8.73 (bs, 1H), 8.83 (bs, 1H). Anal. Calcd. for  $C_{21}H_{26}N_2O_3 \cdot HCl \cdot 0.25H_2O$ : C, 63.79; H, 7.01; N, 7.08. Found: C, 63.59; H, 6.89; N, 7.15.

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**Example 3oo****2-(3,4-Dimethoxyphenyl)-N-methyl-N-{[1S]-1-phenyl-2-(1-pyrrolidinyl)ethyl}acetamide hydrochloride**

The compound was prepared from 3,4-dimethoxyphenyl acetic acid in 65% yield; mp ; 240-242°C;  $^1H$  NMR (300, MHz,  $CDCl_3$ )  $\delta$  2.00-2.35 (m, 4H), 2.85 (s, m, 5H), 3.26 (m, 1H), 3.18 (s, m, 7H), 4.05 (m, 4H), 6.36 (m, 1H), 6.81 (m, 2H), 6.93 (s, 1H), 7.19 (m, 2H), 7.36 (m, 3H). Anal. Calcd. for  $C_{23}H_{30}N_2O_3 \cdot HCl$ : C, ; H, 7.01; N, 7.08. Found: C, 63.59; H, 6.89; N, 7.15.

**Example 3pp****2-(2-Methanesulfonamidophenyl)-N-methyl-N-[(1S)-1-(3-methanesulfon-amidophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide Hydrochloride**5 (1) **2-(2-Nitrophenyl)-N-methyl-N-[(1S)-1-(3-nitrophenyl)-2-(1-pyrrolidinyl)-ethyl]acetamide**

A solution of 2-nitrophenylacetic acid (1.99 g, 11.0 mmol) and 1-hydroxybenzotriazole (1.49 g, 11.0 mmol) in  $\text{CH}_2\text{Cl}_2$  (50 ml) was cooled in an ice bath. To this slurry was added EDCI, and the solution turned brown clear after 30 minutes at room temperature. A solution of (2s)-1-[2-(methylamino)-2-(3-nitrophenyl)ethyl]pyrrolidine<sup>1</sup> (2.49 g, 10.0 mmol) in  $\text{CH}_2\text{Cl}_2$  (5 ml) was added, followed by DIPEA. The solution was stirred in ice bath for 30 minutes and then at room temperature for 18 hours. The reaction was quenched by adding saturated aqueous  $\text{NaHCO}_3$  (20 ml) and stirred for 10 minutes. After separation, the organic layer was washed with water, brine, dried ( $\text{Na}_2\text{SO}_4$ ). The solvent was removed via rotary evaporation and the brown residue was purified by silica column chromatography [2%  $\text{MeOH}/\text{CH}_2\text{Cl}_2$  (2% $\text{NH}_3$ )] to give the product (2.4 g, 58%).

(2) **2-(2-Aminophenyl)-N-methyl-N-[(1R, S)-1-(3-aminophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide**

A suspension of above compound (475 mg, 1.15 mmol) and Raney nickel (50% slurry in water) in ethanol (10 ml) was heated at 50 °C and treated with a solution of hydrazine hydrate (360 ml, 11.5 mmol) in ethanol (2 ml). Upon addition of the reagent, effervescent occurred. The mixture was then stirred at 50 °C for 0.5 h. After cooling, the mixture was filtered through a bed of celite, and the catalyst was washed with hot methanol (10 ml). The combined filtrate and washing was evaporated and dried in vacuum (388 mg, 95%). <sup>1</sup>H NMR ( $\text{DMSO}-d_6$ ):  $\delta$  1.64 (bs, 4H), 2.40 (bs, 2H), 2.58 (m, 2H), 2.66 (s, 3H), 3.06-3.59 (m, 4H), 4.95 (s, 2H), 5.01 (s, 2H), 5.77 (dd, J=4.9, 11.4 Hz, 1H), 6.39-6.48 (m, 4H), 6.63 (d, J=7.6 Hz, 1H), 6.89-7.04 (m, 3H).

To a solution of the diamine (388 mg, 1.11 mmol) in  $\text{CH}_2\text{Cl}_2$  (10 ml) cooled in an ice bath was added pyridine (540 ml, 6.67 mmol), followed by  $\text{MsCl}$  (190 ml, 2.45 mmol) in  $\text{CH}_2\text{Cl}_2$  (5 ml). The mixture was stirred at 0 °C for 0.5 h and then at room temperature for 18 hours. The solution was washed with saturated aqueous  $\text{NaHCO}_3$  (2x50 ml), brine, dried ( $\text{Na}_2\text{SO}_4$ ). The solvent was removed by rotary evaporation and the residue was purified by silica column chromatography to give gummy foam after drying (383 mg, 68%) which was then converted to the  $\text{HCl}$  salt form. Mp: 160 °C (d). <sup>1</sup>H NMR ( $\text{DMSO}-d_6$ ):  $\delta$  1.96 (bs, 4H), 2.77 (s, 3H), 2.97 (s, 3H), 2.98 (s, 3H), 3.14 (m, 2H), 3.57 (m, 3H), 3.97-4.10 (m, 3H), 6.12 (d, J=10.8 Hz, 1H), 7.03-7.37 (m, 8H), 9.10 (s, 1H), 9.81 (s, 1H). Fab MS ( $\text{MH}^+$ ): 509. Anal. Calcd. for  $\text{C}_{23}\text{H}_{33}\text{N}_4\text{O}_5\text{S}_2\text{Cl}$ : C, 48.47; H, 6.43; N, 9.50. Found: C, 48.57; H, 6.07; N, 9.25.

**Example 3qq****2-(2-Iso-butyramidophenyl)-N-methyl-N-[(1S)-1-(3-isobutyramido-phenyl)-2-(1-pyrrolidinyl)ethyl]acetamide Methanesulfonic acid salt**

To a solution of the diamine (132 mg, 0.376 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (5 ml) cooled in an ice bath was added pyridine (182 ml, 2.26 mmol), followed by isobutyryl chloride (119 ml, 1.14 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (5 ml). The mixture was stirred at 0 °C for 0.5 h and then at room temperature for 18 hours. The solution was washed with aqueous saturated NaHCO<sub>3</sub> (2x25 ml), brine, dried (Na<sub>2</sub>SO<sub>4</sub>). TLC indicated that the compound was contaminated by bis-acylated side product. Thus, the solvent was removed by rotary evaporation and the residue was dissolved in MeOH (2 ml), treated with a drop of NaOH (13 N), and stirred at room temperature for 5 minutes. After neutralization with HCl (6N), the solvent was evaporated, the residue was purified by silica column chromatography to give a gummy foam after drying which was then converted to methanesulfonic acid salt (178 mg, 76%). Mp: 143-145 °C; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>): δ 1.08 (m, 12H), 1.88 (m, 2H), 2.00 (m, 2H), 2.31 (s, 3H), 2.56 (m, 2H), 2.65 (s, 3H), 3.18 (m, 2H), 3.36-3.63 (m, 6H), 3.80 (d, J=16.2 Hz, 1H), 4.10 (m, 1H), 6.09 (d; J=10.8 Hz, 1H), 6.90 (d, J=7.6 Hz, 1H), 7.10-7.63 (m, 7H), 9.20 (bs, 1H), 9.41 (s, 1H), 9.92 (s, 1H). Fab MS (MH<sup>+</sup>): 493. Anal. Calcd. for C<sub>30</sub>H<sub>44</sub>N<sub>4</sub>O<sub>6</sub>S: C, 58.86; H, 7.67; N, 9.15. Found: C, 58.77; H, 7.51; N, 8.98.

**EXAMPLE 3rr****4-[4-N-Methylsulfonamido-phenyl]-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)-ethyl]acetamide hydrochloride**

4-(N,N-Dimethylsulfonamido-2-aminophenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide (for preparation see USP 5,688,955) 1.3 g; 2.63 mmol was dissolved in 60 mL of 2:1 MeOH: THF and 2.0 mL of 10 M NaOH was added. After 20 minutes, TLC (95:5 methylene chloride: methanol with 2% ammonia) indicated the reaction was complete. The reaction was neutralized with 10% HCl and concentrated *in vacuo*. The residue was dissolved in methylene chloride and washed with 10% sodium bicarbonate, brine and dried (anh. Na<sub>2</sub>SO<sub>4</sub>). The organic layer was concentrated *in vacuo* and the crude product was purified by flash chromatography using a stepwise gradient of 2% to 8% MeOH: methylene chloride with 2% ammonia to give 300 mg (28%) of desired product, which was treated with 1.0 M HCl in diethyl ether to afford 3rr as a tan solid. mp >260°C(dec.); <sup>1</sup>H NMR (HCl salt, DMSO-d<sub>6</sub>) δ 2.0 (br s, 4H, -CH<sub>2</sub>CH<sub>2</sub>-), 2.8(s, 3H, NCH<sub>3</sub>), 3.0(s, 3H, SO<sub>2</sub>CH<sub>3</sub>), 3.8-4.0(m, 2H), 6.1-6.3(dd, 1H), 7.1-7.5(complex, 9H, aromatic), 9.7(s, 1H). MS(FAB) m/z 415. Anal. (C<sub>22</sub>H<sub>29</sub>N<sub>3</sub>O<sub>3</sub>S · HCl · 0.25 H<sub>2</sub>O): C, 58.46; H, 6.69; N, 9.30. Found: C, 57.89; H, 6.64; N, 9.19.

**Example 3ss****2-(3,4-Dichlorocinnamyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)-ethyl]acetamide hydrochloride**

5 The compound was prepared from 3,4-dichlorocinnamic acid in 70% yield; mp 220-222°C; Anal. Calcd. for  $C_{22}H_{24}Cl_2N_2O.HCl$ : C, 60.08; H, 5.73; N, 6.37. Found: C, 60.25; H, 5.81; N, 6.28.

**Example 3tt**

10 **2-(2-Nitrocinnamyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)-ethyl]acetamide hydrochloride**

The compound was prepared from 2-nitrocinnamic acid in 46% yield; mp 195-197°C; Anal. Calcd. for  $C_{22}H_{23}N_2O_3.HCl$ : C, 63.53; H, 6.30; N, 10.10. Found: C, 63.25; H, 6.38; N, 10.08.

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**Example 3uu**

**(R,S)-1-[2-(Methanesulfonylamino) phenyl-N-methylacetamido]-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane, methanesulfonic acid salt**

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**(R,S)-3-Methoxy-phenylglycine (5, Scheme M)**

NaCN (12.2 g, 0.249 mol) was dissolved in 50 ml of water, and to this solution was added ammonium chloride (13.3 g, 0.249 mol). When all had dissolved, a solution of m-anisaldehyde (33.8 g, 0.249 mol) in 50 ml of EtOH was added slowly. The mixture was stirred at ambient temperature for 2-3 hours. TLC indicated no starting material left. The mixture was taken up in water/toluene (50ml /50 ml). The organic layer was washed with water (50 ml), extracted with 6N HCl (2x30 ml). To hydrolyze the amino cyanide, the hydrochloric extract was refluxed for 4~5 hours. The solution was cooled to room temperature and filtered from some tarry material. The filtrate was cooled in ice bath and the aminoacid salt was collected via filtration, washed with cold water (20 ml), ether, dried at 60 degrees overnight to give 5 (14.5 g, 27%); NMR (DMSO- $d_6$ ),  $\delta$  3.7 (3H, s), 4.29 (1H, s), 6.87 (1H, m), 6.96 (1H, d, J=7.6 Hz), 6.98 (1H, s), 7.26 (1H, t, J=8.0 Hz).

35 **(R,S)-N-Methoxycarbonyl-2-(3-methoxyphenyl)glycine (6)**

R,S-3-Methoxy-phenylglycine (5, 14.5 g, 66.7 mmol) was dissolved in NaOH (1N, 233ml, 233 mmol) and the solution was cooled in ice bath for 15 minutes. To this solution was added methyl chloroformate (7.73 ml, 100 mmol) dropwise. After the addition was complete, the mixture was stirred at room temperature for 2 hours. The pH was adjusted to 10 with 2N NaOH and the stirring was continued for 1 hour. The solution was washed with ether (2x100

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ml), acidified with 6N HCl after addition of EtOAc (100 ml). The aqueous layer was extracted with EtOAc (100 ml), and the combined organic extracts were washed with brine (100 ml), dried over (Na<sub>2</sub>SO<sub>4</sub>), concentrated to yellow syrup 6, (14.4 g, 90%). NMR (CDCl<sub>3</sub>),  $\delta$  3.70 (3H, s), 3.82 (3H, s), 5.35 (1H, d), 5.77 (1H, d), 6.87-7.01 (3H, m), 7.31 (1H, t).

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(R,S)-N-Methoxycarbonyl-2-(3-methoxyphenyl) glycine, pyrrolidine (7)

R,S-N-Methoxycarbonyl-2-(3-methoxyphenyl) glycine (6, 14.4 g, 60.4 mmol) and HOBt (8.97 g, 66.4 mmol) were dissolved in THF (150 ml) and cooled in ice bath. To this solution was added a solution of DCC (12.4 g, 60.4 mmol) in THF (50 ml). After stirring at room temperature for 2 hours, the mixture was cooled in ice bath, and the resulting DCU was filtered, washed with cold THF. The filtrate was treated with a solution of pyrrolidine (5.0 ml, 60.4 mmol) in dichloromethane (50 ml). The solution was stirred at room temperature for 18 hours and concentrated. The residue was taken up in EtOAc (250 ml), and the mixture was washed with NaHCO<sub>3</sub> (saturated, 200 ml), water, brine, dried over Na<sub>2</sub>SO<sub>4</sub>, concentrated to a pale solution (50 ml) which was stored in refrigerator overnight. The more precipitated DCU was filtered off, and the filtrate was dried to give a pale yellow oil 7, (12.8 g, 77%). NMR (CDCl<sub>3</sub>),  $\delta$  1.8 (4H, m), 3.4-3.6 (4H, m), 3.65 (3H, s), 3.8 (3H, s), 5.35 (1H, d), 6.8-7.0 (3H, m), 7.3 (1H, m).

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(R,S)-1-(3-Methoxyphenyl)-1-methylamino-2-(1-pyrrolidino) ethane (8)

LiAlH<sub>4</sub> (5.3 g, 140 mmol) was stirred in anhydrous THF (200 mL) under N<sub>2</sub> and a solution of R, S-N-Methoxycarbonyl-2-(3-methoxyphenyl) glycine, pyrrolidine (12.8 g, 46.6 mmol) in THF (100 ml) was added over 30 minutes at 10~15 degree. The mixture was stirred at room temperature for 0.5 hour then at 55 degree for 2 hours. After cooling in ice bath the mixture was carefully quenched with excess saturated NaHCO<sub>3</sub>, filtered. The filtrate was washed with brine, dried over Na<sub>2</sub>SO<sub>4</sub>, and evaporated to 10.0 grams of colorless oil (8) that was used in further reaction without purification.

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(R,S)-1-(2-Nitrophenyl-N-methylacetamido)-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane (9)

A solution of 2-Nitrophenylacetic acid (1.99 g, 11.0 mmol), HOBt (1.49 g, 11.0 mmol) in THF (50 ml) was cooled in ice bath and treated with a solution of DCC (2.27 g, 11.0 mmol) in THF (5 ml). The mixture was warmed up to room temperature and stirred for 2 hours. After cooling in ice bath the precipitated DCU was filtered, and the filtrate was treated with a solution of R, S-1-(3-Methoxyphenyl)-1-methylamino-2-(1-pyrrolidino) ethane (8) in CH<sub>2</sub>Cl<sub>2</sub> (10 ml). The solution was stirred in N<sub>2</sub> at room temperature for 18 hours and concentrated. The residue was dissolved in EtOAc (100 ml), washed with saturated NaHCO<sub>3</sub>, brine, dried (Na<sub>2</sub>SO<sub>4</sub>). Removal of the solvent, followed by silica column chromatography yielded 3.0 grams of the product (9). NMR (CDCl<sub>3</sub>),  $\delta$  1.74 (4H, bs), 2.52 (2H, bs), 2.67 (2H, bs), 2.77 (1H, m), 2.84 (3H, s), 3.10 (1H, m), 3.83 (3H, s), 4.02-4.31 (2H, m), 6.03 (1H, dd, J = 6.0, 9.8 Hz), 6.80-6.94 (3H, m), 7.26 (1H, m), 7.39-7.46 (2H, m), 7.54-7.59 (1H, m), 8.10 (1H, dd, J = 1.2, 8.0 Hz).

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(R,S)-1- (2-Aminophenyl-N-methylacetamido)-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane

A suspension of R,S-1-(2-nitrophenyl-N-methylacetamido)-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane (8) (1.3 g, 3.27 mmol) and Raney Ni (1 spatula) in EtOH (20 ml) was stirred at 50 degree and treated with a solution of hydrazine hydrate in EtOH (10 ml). After effervescent stopped, the mixture was stirred at 55 degree for 0.5 hour, then cooled to room temperature, filtered through a bed of celite, washed with hot MeOH (20 ml). The combined filtrate and washing was concentrated, dried to yellow residue (1.2 g) of amino compound that was used with further purification.

10 (R,S)-1- [2-(Methanesulfonylamino) phenyl-N-methylacetamido]-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane, methanesulfonic acid salt (3uu)

To a solution of R, S-1-(2-aminophenyl-N-methylacetamido)-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane (1.2 g, 3.24 mmol) in  $\text{CH}_2\text{Cl}_2$  (20 ml) was added pyridine (0.79 ml, 9.72 mmol), followed by a solution of  $\text{MsCl}$  (0.376 ml, 4.86 mmol). The mixture was stirred at room temperature for 18 hours. The mixture was washed with water (20 ml), brine, dried ( $\text{Na}_2\text{SO}_4$ ). The solution was concentrated, and the residue was purified via silica column chromatography to give a yellowish oil (1.20 g, 83%). 251 mg of the free base was converted to methane sulfonic acid salt, 3uu. M p: 135 °C (decomposed). NMR ( $\text{DMSO}-d_6$ ),  $\delta$  1.92 (2H, bs), 2.02 (2H, bs), 2.32 (3H, s), 2.72 (3H, s), 2.97 (3H, s), 3.19 (2H, m), 3.56-3.97 (8H, m), 4.03-4.12 (2H, m), 6.08 (1H, d,  $J = 12.0$  Hz), 6.74 (1H, s), 6.81 (1H, dd,  $J = 2.3, 8.0$  Hz), 7.16-7.39 (5H, m), 9.07 (1H, s), 9.26 (1H, bs). MS (FAB)  $m/z$  446. Anal. (C, H, N)  $\text{C}_{23}\text{H}_{21}\text{N}_3\text{O}_4\text{S}\cdot\text{CH}_3\text{SO}_3\text{H}\cdot 0.2\text{H}_2\text{O}$ .

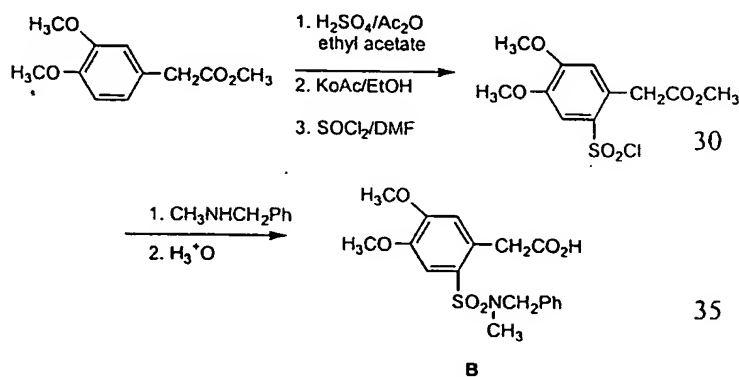
Example 3vv

25 (R,S)-1- [2-(Methanesulfonylamino) phenyl-N-methylacetamido]-1-(3-hydroxyphenyl)-2-(1-pyrrolidino)-ethane, methanesulfonic acid salt

A solution of R,S-1-[2-(methanesulfonylamino)phenyl-N-methylacetamido]-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane (3uu, 196 mg, 0.440 mmol) in  $\text{CH}_2\text{Cl}_2$  (15 ml) was cooled to -70 degree and treated with a solution of  $\text{BBr}_3$  (1.0 M in  $\text{CH}_2\text{Cl}_2$ , 1.45 ml, 1.45 mmol) in  $\text{CH}_2\text{Cl}_2$  (2 ml). The mixture was stirred at -70 degree for 1 hour, then slowly warmed up to room temperature overnight. The mixture was carefully quenched at 0 degree with MeOH (5 ml) and the solution was evaporated under reduced pressure. The residue was stirred in 10 ml of anhydrous MeOH/ $\text{Et}_2\text{O}$  (1/1) for 6 hours and filtered. The white solid was taken up in  $\text{CHCl}_3$  (50 ml) and  $\text{NaHCO}_3/\text{Na}_2\text{CO}_3$  (pH~10)(50 ml). The organic layer was washed with brine, dried ( $\text{Na}_2\text{SO}_4$ ). After removal of the solvent, the residue was dissolved in MeOH (5 ml) and treated with  $\text{CH}_3\text{SO}_3\text{H}$  (0.026 ml, 0.404 mmol). The solvent was evaporated and the residue was sonicated in ether. The precipitate was filtered, dried to give 3vv, (0.164 g, 84%). Mp: 232-234 °C. NMR ( $\text{DMSO}-d_6$ ),  $\delta$  1.93 (2H, bs), 2.02 (2H, bs), 2.32 (3H, s), 2.70 (3H, s), 2.97 (3H, s), 3.16 (2H, bs), 3.40-3.80 (4H, m), 4.03-4.12 (2H, m), 6.04 (1H, d,  $J = 9.6$  Hz), 6.63-6.72 (3H, m), 7.14-7.39 (5H, m), 9.06 (1H, s), 9.21 (1H, bs), 9.56 (1H, s). MS (FAB)  $m/z$  432. Anal. (C, H, N)  $\text{C}_{22}\text{H}_{20}\text{N}_3\text{O}_4\text{S}\cdot\text{CH}_3\text{SO}_3\text{H}\cdot 0.2\text{H}_2\text{O}$ .

**Example 3ww****2-(3-Indolyl)-N-methyl-N-[(1S)-1-phenyl-2-[(3S)-1-pyrrolidin-3-ol]ethyl]-acetamide hydrochloride**

- 5 Compound 3ww was prepared from indole-3-acetic acid (477 mg; 2.72 mmol), DCC (1.12 g; 5.44 mmol), pyridine (0.440 mL; 5.44 mmol) and S-(-)-3-pyrrolidinol (600 mg; 2.72 mmol, for preparation see EP 0398 720 A2) in 15 mL of dry methylene chloride. After stirring at room temperature for 24 h, TLC (95:5 methylene chloride:methanol w/2% ammonia) indicated the reaction was complete. The reaction was quenched with sat. sodium bicarbonate and the layers were separated. The organic layer was washed with brine, dried over anhydrous sodium sulfate, filtered and conc. *in vacuo* to give 2.04 g of a viscous yellow oil which was purified by flash chromatography using a stepwise gradient of 2% to 3% methanol: methylene chloride with 2% ammonia to yield 700 mg (69%) of desired compound which was converted to the hydrochloride salt with HCl/ether to give 720 mg of 3ww. m.p. 142 °C(dec.); <sup>1</sup>H NMR (HCl salt, CDCl<sub>3</sub>, 300 MHz) δ 2.1 (br, m, 4H), 2.8 (s, 3H), 4.5 (m, 1H), 6.3 (br, m, 1H), 7.2 (br, m, 1H), 7.3 (complex, 4H, aromatic), 7.5-7.6 (d, 2H), 7.8 (d, 2H). Fab MS (MH<sup>+</sup>): 377. Anal. Calcd for C<sub>23</sub>H<sub>27</sub>O<sub>3</sub>N<sub>3</sub>·HCl: C, 63.29; H, 7.04; N, 9.63. Found C, 63.15; H, 7.03; N, 9.57.

**Example 3xx****2-(2-N-Benzyl-2-N-methylsulfamoyl-3,4-dimethoxyphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride**

- 40 Compound B was prepared from methyl 3,4-dimethoxyphenyl acetate following the literature procedure[J. Het. Chem. 29, 1667 (1992)] and condensed with the diamine in usual fashion to give 3xx in 60% yield; mp 188-190°C; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 1.88 (m, 4H), 2.64 (s, 3H), 2.85-3.25 (m, 4H), 2.91 (s, 3H), 3.90 (s, 3H), 3.94-4.28 (m, 2H), 3.95 (s, 3H), 4.30-4.60 (m, 4H), 6.48 (m, 1H), 7.15-7.40 (m, 11H), 7.55 (s, 1H). Anal. Calcd. for C<sub>31</sub>H<sub>39</sub>N<sub>3</sub>O<sub>5</sub>S·HCl·0.5 H<sub>2</sub>O: C, 60.92; H, 6.76; N, 6.88. Found: C, 60.73; H, 6.99; N, 6.82.
- 45



**EXAMPLE 3yy****2-(N-Methylsulfonamido-2-aminophenyl)-N-methyl-N-[(1R)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide methane sulfonate**

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Compound 3yy was prepared using the same synthetic scheme as described in USP 5,688,955 using (R) -1-[2-methylamino-2 phenyl]ethyl] pyrrolidine (for preparation see J. Med. Chem. 34, 1991 pp181, Costello, G.F. et. al m.p. 179-181°C: <sup>1</sup>H NMR (Mesylate salt, CDCl<sub>3</sub>, 300 MHz) δ 2.0-2.2 (br, m, 4H), 2.8 (s, 3H), 3.0 (s, 3H), 3.6 (d, 2H), 6.2-6.3 (d, 1H), 7.1 (m, 3H), 7.2 (m, 1H), 7.3 (m, 3H), 7.7 (d, 2H). Fab MS (MH<sup>+</sup>): 415. Anal. Calcd. for C<sub>23</sub>H<sub>33</sub>O<sub>6</sub>N<sub>3</sub>S<sub>2</sub>: C, 53.99; H, 6.50; N, 8.21. Found C, 53.98; H, 6.41; N, 8.10.

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**EXAMPLE 3zz****(R,S)-1-(4-Trifluoromethylphenyl-N-methylacetamido)-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane, methanesulfonic acid salt**

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The procedure is the same as that of 3uu. Yield: 74%. Mp.: 166-168 °C. NMR (CDCl<sub>3</sub>), δ (ppm): 2.11 (2H, m), 2.16-2.32 (2H, m), 2.81 (3H, s), 2.85-2.98 (4H, m), 3.12-3.21 (1H, m), 3.75 (3H, s), 3.83 (1H, m), 4.05-4.33 (4H, m), 6.30 (1H, dd, J = 2.6, 12.0 Hz), 6.67 (1H, d, J = 1.8 Hz), 6.75 (1H, d, J = 7.6 Hz), 6.87 (1H, dd, J = 2.4, 8.3 Hz), 7.30 (1H, m), 7.45 (1H, d, J = 8.1 Hz), 7.57 (1H, d, J = 8.1 Hz). MS (FAB) m/z 421. Anal. (C, H, N) C<sub>23</sub>H<sub>27</sub>N<sub>2</sub>O<sub>3</sub>F<sub>3</sub>·CH<sub>3</sub>SO<sub>3</sub>H.

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**EXAMPLE 3aaa****(R,S)-1-(4-Trifluoromethylphenyl-N-methylacetamido)-1-(3-hydroxyphenyl)-2-(1-pyrrolidino)-ethane, methanesulfonic acid salt**

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The procedure is the same as that of 3vv. Yield: 38.5%. Mp: 158-160 °C. NMR (CDCl<sub>3</sub>), δ (ppm): 2.01-2.14 (4H, m), 2.73 (3H, s), 2.82 (3H, s), 2.94 (2H, m), 3.30 (1H, m), 3.76 (1H, m), 4.03-4.14 (4H, m), 6.20 (1H, dd, J = 3.3, 11.0 Hz), 6.63 (1H, d, J = 7.9 Hz), 6.86 (1H, dd, J = 1.8, 8.0 Hz), 7.06 (1H, s), 7.18 (1H, t, J = 8.0 Hz), 7.41 (2H, d, J = 8.0 Hz), 7.56 (2H, d, J = 8.0 Hz). MS (FAB) m/z 407. Anal. (C, H, N) C<sub>22</sub>H<sub>25</sub>N<sub>2</sub>O<sub>3</sub>F<sub>3</sub>·1.1CH<sub>3</sub>SO<sub>3</sub>H.

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**EXAMPLE 3bbb****2-Fluorophenyl-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]-acetamide hydrochloride**

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Compound 3bbb was prepared using the same general EDCI/DIPEA coupling procedure as described in USP 5,688,955 with 2-fluorophenylacetic acid (415 mg; 2.69 mmol), HOBT (363 mg; 2.69 mmol), EDCI (514 mg; 2.69 mmol), N,N-diisopropylethylamine (0.63 mL; 3.66 mmol), and (1S) 1-[(2-methylamino-2-phenyl)ethyl]pyrrolidine (500 mg; 2.44 mmol) in 10

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mL of dry methylene chloride at room temperature. After 24h, TLC(95:5 methylene chloride:methanol w/2% ammonia) indicated the reaction was complete. The reaction solution was quenched with sat. sodium bicarbonate and the layers were separated. The organic layer was washed with brine, dried over anh. sodium sulfate, filtered and conc. *in vacuo* to give 900 mg of a dark brown oil which was purified by flash chromatography using a stepwise gradient of 2% to 4% methanol:methylene chloride with 2% ammonia to yield 750 mg(90%) of desired product which was converted to the hydrochloride salt with HCl/ether to give 880 mg of **3bbb**. m.p. 255°C(dec.); <sup>1</sup>H NMR (HCl salt, CDCl<sub>3</sub>, 300 MHz) δ 2.0 (br, m, 4H), 2.1-2.2 (br, m, 2H), 2.9 (s, 3H), 3.8-4.0 (dd, 4H), 7.0-7.4 (complex, 9H, aromatic). Fab MS (MH<sup>+</sup>): 340. Anal. Calcd. for C<sub>21</sub>H<sub>25</sub>ON<sub>2</sub>FHCl : C, 66.97; H, 6.95; N, 7.43. Found C, 66.76; H, 6.90; N, 7.43.

#### EXAMPLE 3ccc

#### 15 4-Fluorophenyl-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride (3ccc)

Compound 3ccc was prepared using the same general EDCI/DIPEA coupling procedure from USP 5, 688,955 with 4-fluorophenylacetic acid (415 mg; 2.69 mmol), HOBT (363 mg; 2.69 mmol), EDCI (514 mg; 2.69 mmol), N,N-diisopropylethylamine (0.63 mL; 3.66 mmol) and (1S) 1-[(2-methylamino-2-phenyl)ethyl]pyrrolidine (500 mg; 2.44 mmol) in 10 mL of dry methylene chloride at room temperature. After 24h, TLC(95:5 methylene chloride:methanol w/2% ammonia) indicated the reaction was complete. The reaction was quenched with sat. sodium bicarbonate and the layers were separated. The organic layer was washed with brine, dried over anh. sodium sulfate, filtered and conc. *in vacuo* to give 900 mg of a dark brown oil which was purified by flash chromatography using a stepwise gradient of 2% to 3% methanol: methylene chloride with 2% ammonia to yield 800 mg (96%) of desired product which was converted to the hydrochloride salt with HCl in ether to give 3ccc. m.p. >260°C(dec.); <sup>1</sup>H NMR (HCl salt; CDCl<sub>3</sub>, 300 MHz) δ 2.0 (br, m, 4H), 2.1-2.2 (br, m, 2H), 2.9 (s, 3H), 3.8-4.0 (dd, 4H), 7.0-7.4 (complex, 9H, aromatic). Fab MS (MH<sup>+</sup>): 340. Anal Calcd for C<sub>21</sub>H<sub>25</sub>ON<sub>2</sub>HCl : C, 66.82; H, 6.95; N, 7.43. Found C, 66.81; H, 6.94; N, 7.48

#### Example 3ddd

#### 35 (E)- 4-[2-(2-Amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]ethyl]acetamido]4-oxo-2-butenoic acid hydrochloride

To a solution of 3y (1.4 g, 2.63 mmol) in THF:CH<sub>3</sub>OH (1:1, 20 mL) at room temperature was added 1M LiOH aqueous solution (5.3 mL, 5.26 mmol) and the reaction mixture was stirred for 8 h. Progress of reaction was followed by TLC and reaction mixture was acidified to pH 4.0 from 1N HCl. The solvent was removed under reduced pressure. The residue was triturated with CH<sub>2</sub>Cl<sub>2</sub> (3x45 mL). The combined organic layer was washed with sat. salt solution which resulted in the precipitation of the compound. The solid was filtered off, washed with a smmal amount of water, anhydrous ether, and dried to give 3ddd 0, 0.85 g (59%); mp 205-207°C (d); <sup>1</sup>H NMR (300 MHz, DMSO-d<sub>6</sub>) δ 1.93 (m, 4H), 2.84 (s, 3H), 3.00-3.75 (m, 6H), 3.98 (d, J = 15.0 Hz, 1H), 4.05 (m, 1H), 4.35 (d, J = 16.5 Hz, 1H), 6.12 (m,

1H), 6.65 (d, J = 15.4 Hz, 1H), 7.25-7.38 (m, 5 H), 7.55 (s, 1H), 7.79 (d, J = 15.0 Hz, 1H), 8.31 (s, 1H). Anal. Calcd. for  $C_{23}H_{27}Cl_2N_3O_4 \cdot HCl \cdot NaCl \cdot 1.5 H_2O$ : C, 47.94; H, 4.99; N, 6.71. Found: C, 47.98; H, 4.92; N, 6.57.

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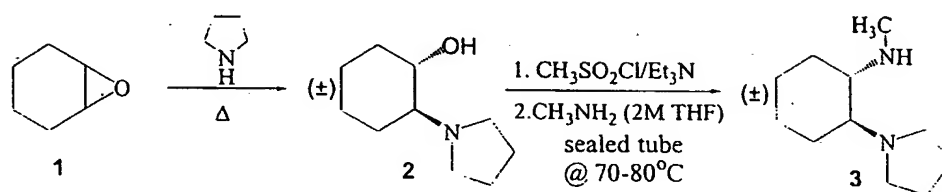
### Compounds of formula IV

#### Intermediates

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The following intermediates were prepared.

#### Synthesis of Diamine 3



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#### (±)-trans-2-Pyrrolidinyl-N-methylcyclohexylamine (3)

The racemic diamine (3) was prepared by a number of procedure reported in the literature.<sup>10,11</sup>

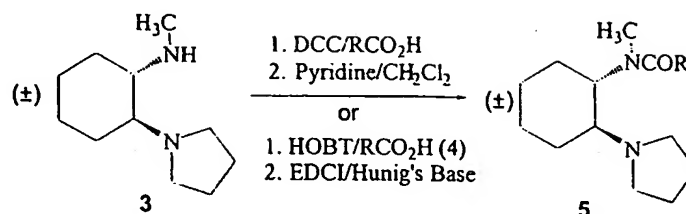
Alternatively, the amine was also prepared from cyclohexene oxide (1) following the procedure described in Scheme I and the literature<sup>12</sup> in 70% overall yield as brown oil. A sample was purified by the distillation (b.p. 75-82°C/ 1.0 mm, lit.<sup>2</sup> b.p. 76-80°C/1.2 mm); <sup>1</sup>H-NMR (200 MHz,  $CDCl_3$ )  $\delta$  1.04-1.36 (m, 4H), 1.49-1.89 (m, 8H), 2.18 (d, J = 5.0 Hz, 1H), 2.52 (s, 3H), 2.56-2.70 (m, 4H), 2.80-2.93 (m, 1H), 7.75 (bs, 1H). The corresponding chiral amine (3) could be prepared following the literature procedures.

25

#### Ref.

- (10) Szmuszkovicz, J.; Von Voigtlander, P. F. *J. Med. Chem.* **1982**, *25*, 1125-1126.  
 (11) DeCosata, B.; George, C.; Rothman, R. B.; Jacobson, A. E.; Rice, K. E. *FEBS Lett.* **1987**, *223*, 335-339.  
 (12) Freeman, J. P.; Michalson, E. T.; D'Andrea, S. V.; Baczynskyj, L.; Von Voigtlander, P. F.; Lahti, R. A.; Smith, M. W.; Lawson, C. F.; Scahill, T. A.; Mizesak, S. A.; Szmuszkovicz, J. *J. Med. Chem.* **1991**, *34*, 1891-1896.

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**Synthesis of Arylacetamides****General procedure for the preparation of aryl acetamides (±) 5 HCl**

To a stirred solution of aryl acetic acid (4) (1.5 mmol) in 20 mL of dry  $\text{CH}_2\text{Cl}_2$  was added pyridine (0.5 mmol) at  $0 \rightarrow 5^\circ\text{C}$  under a nitrogen atmosphere.  $\text{N,N}'$ -Dicyclohexylcarbodiimide (2.0 mmol) was added in one portion and the reaction mixture was continued stirring for 30 min while warming to room temperature. A solution of the (±) 3 (1.0 mmol) in 10 mL of dry  $\text{CH}_2\text{Cl}_2$  was added and the progress of the reaction was monitored by TLC in solvent system corresponds to  $\text{CHCl}_3:\text{CH}_3\text{OH}:28\% \text{NH}_4\text{OH}$  (93:5:2). After disappearance of the diamine 3, the reaction mixture was quenched with saturated  $\text{NaHCO}_3$  and stirring was continued for addition 15 min. The precipitated  $\text{N,N}'$ -dicyclohexylurea (DCU) was removed by filtration and the filter cake was washed with additional amounts of  $\text{CH}_2\text{Cl}_2$ . The combined filtrate was evaporated to dryness and the residue was purified either on a silica gel column or using Chromatran silica gel plates from the solvent system mentioned for each compound to give (±) 5 as free base. The hydrochloride salts were prepared from dissolving (±) 5 in minimum amount of  $\text{CH}_2\text{Cl}_2$  and addition of 2.0 equivalents of 1M etherial HCl. The solvents were removed under reduced pressure and the HCl salts were recrystallized from the solvents indicated below. The yields given below are for overall steps.

**Example 103****(±)-trans-2-Nitro-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]phenylacetamide****Hydrochloride [(±) 5a HCl]****ADL-01-0012-3**

Prepared from 2-nitrophenylacetic acid [solvent for purification-  $\text{CH}_2\text{Cl}_2:\text{CH}_3\text{OH}:28\%\text{NH}_4\text{OH}$  (98:2:2)]: yield 21% as a white solid (2-propanol); mp  $267-269^\circ\text{C}$  (d);  $^1\text{H}$  NMR((200 MHz,  $\text{CDCl}_3$ )  $\delta$  1.00-1.44 (m, 2H), 1.60-2.35 (m, 8H), 2.85 (m, 1H), 3.15 (s, 3H), 3.18-3.35 (m, 4H), 3.40 (m, 1H), 3.85 (m, 1H), 4.33 (dd,  $J=10.0$  Hz, 2H), 4.64 (m, 1H), 7.35

(m, 1H), 7.56 (m, 2H), 8.05 (d, J = 7.8 Hz, 1H), 11.02 (bs, 1H). Anal. Calcd for  $C_{19}H_{27}N_3O_3 \cdot HCl$ : C, 59.75; H, 7.39; Cl, 9.28; N, 11.00. Found: C, 59.98; H, 7.38; 8.96; N, 10.85.

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#### Example 104

##### (±)-trans-2-Amino-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]phenylacetamide Hydrochloride [(±) 5b HCl]

###### ADL-01-0014-9

- 10 To a solution of (±) 5a HCl (0.5 g, 1.31 nmol) in 30 mL of  $CH_3OH$  was added 10% Pd/C (100 mg) and hydrogenated at 50 PSI in a Parr Apparatus at ambient temperature for 3 h. The catalyst was removed by filtration through a celite pad and washed with hot  $CH_3OH$  and the combined filtrate was evaporated to dryness. The residue was recrystallized from 2-propanol to give (±) 5b HCl as a white solid, 0.45 g (95%); mp 213-215°C;  $^1H$  NMR(200 MHz,  $CDCl_3$ ) δ 1.05-1.40 (m, 2H), 1.65-2.25 (m, 8H), 3.10 (s, 3H), 2.90-3.25 (m, 4H), 3.50 (d, J = 12.0, 1H), 3.65 (m, 1H), 3.88 (m, 1H), 4.20 (d, J = 12.5 Hz, 1H), 4.70 (m, 1H), 6.65 (m, 2H), 7.00 (m, 2H), 7.25 (bs, 2H). Anal. Calcd for  $C_{19}H_{29}N_3O \cdot HCl \cdot 0.5H_2O$ : C, 63.23; H, 8.66; N, 11.64. Found: C, 63.59; H, 8.76; N, 11.61.
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- 20

#### Example 105

##### (±)-trans-2-Nitro-4,5-dichloro-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5c HCl]

###### ADL-01-0015-6

- 25 The compound was prepared according to the literature method (DeCosata, B.; Linda, B.; Rothman, R. B.; Jacobson, A. E.; Bykov, V.; Pert, A.; Rice, K. E. FEBBS Lett. 1989, 249, 178-182);  $^1H$  NMR(200 MHz,  $CDCl_3$ ) δ 1.15-1.45 (m, 2H), 1.55-2.30 (m, 8H), 3.10 (s, 3H), 2.85-3.20 (m, 4H), 3.40 (m, 1H), 3.88 (m, 1H), 4.25 (d, J = 14.5 Hz, 1H), 4.45 (d, J = 15.0 Hz, 1H), 4.65 (m, 1H), 7.70 (s, 1H), 8.13 (s, 1H). Anal. Calcd for  $C_{19}H_{23}Cl_2N_3O_3 \cdot HCl$ : C, 50.62; H, 5.81; N, 9.32. Found: C, 50.61; H, 5.61; N, 9.20.
- 30

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#### Example 106

##### (±)-trans-2-Amino-4,5-dichloro-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5d HCl]

###### ADL-01-0016-4

- 40 Obtained from (±) 5c HCl following the literature procedure (DeCosata, B.; Linda, B.; Rothman, R. B.; Jacobson, A. E.; Bykov, V.; Pert, A.; Rice, K. E. FEBBS Lett. 1989, 249, 178-182);  $^1H$  NMR(200 MHz,  $CDCl_3$ ) δ 1.10-1.40 (m, 4H), 1.48-2.20 (m, 8H), 3.00 (s, 3H), 3.10-3.30 (m, 4H), 3.55 (d, J = 14.0 Hz, 1H), 3.85 (d, J = 14.0 Hz, 1H), 4.50 (m, 1H), 6.75 (s, 1H), 7.08 (s, 1H). Anal. Calcd for  $C_{19}H_{27}Cl_2N_3O \cdot HCl \cdot 0.75H_2O$ : C, 52.54; H, 6.84; N, 9.67. Found: C, 52.561; H, 6.63; N, 9.33.

**Example 107****(±)-trans-2-Methanesulfonamido-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5e HCl]**5 **ADL-01-0025-5**

To a solution of free base of (±) 5b (1.0 g, 3.2 mmol) in 40 mL of dry CH<sub>2</sub>Cl<sub>2</sub> at 0°C under a nitrogen atmosphere was added Et<sub>3</sub>N (1.86 g, 18.4 mmol). A solution of methanesulfonyl chloride (1.14 g, 9.92 mmol) in 15 mL of dry CH<sub>2</sub>Cl<sub>2</sub> was added dropwise within 15 min. After 2 h at room temperature TLC [solvent system: CHCl<sub>3</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH (93:5:2)] showed still starting material was present. Additional amounts of Et<sub>3</sub>N (1.86 g) and methanesulfonyl chloride (1.14 g) were added and stirring was continued for another 2 h by this time no starting material was present in the reaction mixture. After the mixture was diluted with 40 mL CH<sub>2</sub>Cl<sub>2</sub> of, it was washed with saturated NaHCO<sub>3</sub>, water, saturated salt solution, and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. Removal of solvent under reduced pressure gave the bis-sulfoamide as a brown foam which was used directly in the following hydrolysis.

To a solution of bis-sulfonamide (1.0 g, 2.12 mmol) in 60 mL of CH<sub>3</sub>OH:THF (2:1) was added 10 M aqueous NaOH (0.96 mL, 9.6 mmol).<sup>13</sup> The mixture was stirred at room temperature for 30 min and then acidified with 1N HCl. The solvent was evaporated under reduced pressure and the residue was redissolved in CH<sub>2</sub>Cl<sub>2</sub>. The CH<sub>2</sub>Cl<sub>2</sub> layer was then washed with 5% NaHCO<sub>3</sub>, saturated salt solution, and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. Removal of solvent under reduced pressure chromatography on a silica gel column [solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (95:5:2)] gave the mono-sulfonamide (free base) as an oil; <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.05-1.95 (m, 12H), 2.45-2.80 (m, 5H), 2.95 (s, 3H), 3.10 (s, 3H), 3.50 (d, J = 13.8 Hz, 1H), 3.65 (m, 1H), 3.85 (d, J = 14.0 Hz, 1H), 4.45 (m, 1H), 7.05 (m, 1H), 7.15 (m, 2H), 7.45 (d, J = 8.5 Hz, 1H). The hydrochloride salt was prepared by dissolving the free base in CH<sub>2</sub>Cl<sub>2</sub> and adding 1.2 equivalents of 1M etherial HCl and recrystallizing from 2-propanol to give (±) 5e HCl as beige colored solid, 0.37 g (38%); mp 229-231°C; <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.10-2.20 (m, 12H), 2.90-3.20 (m, 4H), 3.00 (s, 3H), 3.15 (s, 3H), 3.50 (m, 1H), 3.65 (d, J = 13.5 Hz, 2H), 3.80 (m, 1H), 4.40 (m, 1H), 7.05-7.30 (m, 3H), 7.60 (d, J = 8.0 Hz, 1H), 8.90 (bs, 1H). Anal. Calcd for C<sub>20</sub>H<sub>31</sub>N<sub>3</sub>O<sub>3</sub>S.HCl.0.25H<sub>2</sub>O: C, 55.28; H, 7.54; N, 9.67. Found: C, 55.40; H, 7.39; N, 9.49.

35 **Ref.**

(13) Li, C.-S.; Black, W. C.; Chan, C.-C.; Ford-Hutchinson, A. W.; Gauthier, J.-Y.; Gordon, R.; Guay, D.; Kargman, S.; Lau, C. K.; Mancini, J.; Ouimet, N.; Roy, P.; Vickers, P.; Wong, E.; Young, R. N.; Zamboni, R.; Prasit, P. *J. Med. Chem.* 1995, 38, 4897-4905.

**Example 108****N-[2-(±)-trans-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamido]glycine  
Hydrochloride [(±) 5f HCl]**5 **ADL-01-0028-9**

To a stirred solution of (±) 5b (free base, 1.0 g, 3.2 mmol) in 15 mL of dry DMF at room temperature under a nitrogen atmosphere was added 95% NaH (0.083 g, 3.3 mmol). After stirring at room temperature for 30 min, the turbid solution was added to a stirred solution of *tert*-butyl bromoacetate (0.66 g, 3.4 mmol) in 10 mL of dry DMF. The reaction mixture was continued stirring for 72 h however TLC of the reaction mixture [solvent system: CHCl<sub>3</sub>:CH<sub>3</sub>OH:28% NH<sub>4</sub>OH (93:5:2)] showed still starting material was present. The solvent was removed under reduced pressure and the residue was partitioned between CH<sub>2</sub>Cl<sub>2</sub>/water. The product was purified on a silica gel column from CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH (9:1) and was recystallized from CH<sub>2</sub>Cl<sub>2</sub>:Et<sub>2</sub>O (1:1) to give the corresponding *tert*-butyl ester, 0.16 (12%); <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.05-1.35 (m, 4H), 1.35 (s, 9H), 1.55-2.20 (m, 8H), 2.92 (b, 4H), 3.12 (s, 3H), 3.45 (m, 1H), 3.60 (d, J = 14.0 Hz, 2H), 3.78 (bt, 2H), 3.95 (m, 1H), 5.75 (b, 1H), 6.38 (d, J = 6.5 Hz, 1H), 6.60 (t, J = 5.5 Hz, 1H), 7.00 (m, 2H). The starting material was also recovered in 50% yield.

20

The *tert*-butyl ester (0.16 g, 0.372 mmol) was suspended in 10 mL of 4N aqueous HCl and added one drop of anisole and the mixture was stirred at room temperature for 24 h. The solvent was evaporated under reduced pressure and the residue was redissolved in CH<sub>3</sub>CN and filtered. The filtrate was evaporated under reduced pressure and the residue was recrystallized from 2-propanol:ether (1:1) to give (±) 5f HCl as a white solid, 0.070 g (42%); mp 212-214°C (d); <sup>1</sup>H NMR (200 MHz, DMSO-d<sub>6</sub>) δ 1.15-2.25 (m, 12H), 2.90 (m, 1H), 3.05 (s, 3H), 3.14-3.70 (m, 6H), 3.85 (bs, 2H), 4.55 (b, 1H), 6.37 (d, J = 6.0 Hz, 1H), 6.55 (t, J = 5.0 Hz, 1H), 6.95 (m, 2H), 9.80 (b, 1H). Anal. Calcd for C<sub>21</sub>H<sub>31</sub>N<sub>3</sub>O<sub>3</sub>·HCl·H<sub>2</sub>O: C, 58.93; H, 8.00; N, 9.81. Found: C, 58.79; H, 7.64; N, 9.43.

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**Example 109****(±)-trans-4-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide  
Hydrochloride [(±) 5g HCl]**35 **ADL-01-0066-9**

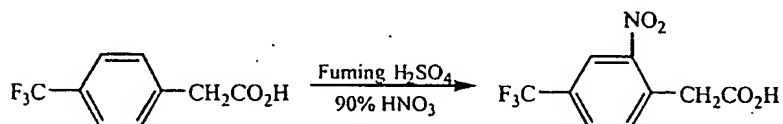
To a solution of 4-trifluoromethylphenyl acetic acid (1.45 g, 7.08 mmol) in 10 mL of dry CH<sub>2</sub>Cl<sub>2</sub> under a nitrogen atmosphere was added 1-hydroxybenzotriazole hydrate (HOBT) (0.95 g, 7.08 mmol) and stirred. The reaction mixture was cooled to 0→5°C and added solid EDCI ([1-(3-dimethylaminopropyl)-3-ethyl-carbodiimide HCl])(1.35 g, 7.08 mmol) and stirred at this temperature for 30 min. A solution (±) 3 (1.0 g, 5.48 mmol) in 10 mL of dry CH<sub>2</sub>Cl<sub>2</sub> was added followed by N,N-diisopropylethylamine (Hunig's Base) (0.915 g, 7.08 mmol). The reaction mixture was stirred for 24 h while warming to the room temperature. The reaction mixture was then poured on to excess of ice-cold saturated aqueous NaHCO<sub>3</sub> solution and stirred for 30 min. After dilution with CH<sub>2</sub>Cl<sub>2</sub>, the organic was separated, washed with saturated salt solution, and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. Removal of solvent

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gave a brown oil which was chromatographed on a silica gel column [solvent system:  $\text{CH}_2\text{Cl}_2$ :  $\text{CH}_3\text{OH}$ : 28%  $\text{NH}_4\text{OH}$  (99:1:2)] to give the desired product as free base. The hydrochloride salt was prepared from 1M ethereal HCl and recrystallized from  $\text{CH}_2\text{Cl}_2$ :  $\text{Et}_2\text{O}$  (1:1) to give  
 5  $(\pm)$  5g HCl as a cream colored solid, 0.68 g (30%); 213-215°C;  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  1.02-1.47 (m, 4H), 1.52-2.22 (m, 8H), 2.75-2.90 (m, 2H), 2.94 (s, 3H), 3.07 (m, 1H), 3.37 (m, 1H), 3.62 (d,  $J = 15.0$  Hz, 1H), 3.77 (m, 1H), 4.17 (d,  $J = 15.0$  Hz, 1H), 4.57 (m, 1H), 7.30 (d,  $J = 8.0$  Hz, 2H), 7.38 (d,  $J = 8.0$  Hz, 2H). Anal. Calcd for  $\text{C}_{20}\text{H}_{27}\text{F}_3\text{N}_2\text{O} \cdot \text{HCl} \cdot 0.25\text{H}_2\text{O}$ : C, 58.68; H, 7.02; N, 6.84. Found: C, 58.68; H, 6.84; N, 6.69.

# 10 Nitration of 4-trifluoromethylphenyl acetic acid :

General procedure:



# 15 Preparation of 2-nitro-4-trifluoromethylphenyl acetic acid [4, R = 2-NO<sub>2</sub>(4-CF<sub>3</sub>) - C<sub>6</sub>H<sub>4</sub>CH<sub>2</sub>]

20 To a solution of 4-trifluoromethylphenyl acetic acid (2.5 g, 12.25 mmol) in 8 mL of glacial acetic acid at 0°C under an anhydrous atmosphere was added 5 mL of fuming  $\text{H}_2\text{SO}_4$  (11%  $\text{SO}_3$ ) (caution !) followed by cautious addition of 90%  $\text{HNO}_3$  (3.5 mL, 73.14 mmol) within 10 min. The reaction mixture was then stirred at room temperature for 2 h and poured into ice-water. The resulting solid was filtered and washed with cold deionized water to give the  
 25 desired product after drying as off-white solid, 2.5 g (82%);  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  4.02 (s, 2H), 7.41 (d,  $J = 8.0$  Hz, 2H), 7.74 (d,  $J = 8.0$  Hz, 2H), 8.28 (s, 1H). The product was used directly into the following reactions.

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## Example 110

### $(\pm)$ -trans-2-Nitro-4-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [4] 5h HCl

ADL-01-0065-1

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Prepared from 2-nitro-4-trifluoromethylphenyl acetic acid following the procedure described in Example II to give  $(\pm)$  5h HCl as cream colored solid in 56% yield; mp 259-261°C (d);  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  1.10-1.42 (m, 4H), 1.51-2.25 (m, 8H), 2.95-3.25 (m, 3H), 3.14 (s, 3H), 3.40 (m, 1H), 3.90 (m, 1H), 4.35 (d,  $J = 13.8$  Hz, 1H), 4.55 (d,  $J = 14.0$  Hz, 1H), 4.60 (m, 1H), 7.80 (dd,  $J = 7.8$  Hz, 2H), 8.25 (s, 1H). Anal. Calcd for  $\text{C}_{20}\text{H}_{26}\text{F}_3\text{N}_3\text{O}_3 \cdot \text{HCl} \cdot 0.25\text{H}_2\text{O}$ : C, 52.86; H, 6.10; N, 9.25. Found: C, 52.85; H, 6.02; N, 9.13.

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**Example 111****(±)-trans-2-Amino-4-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5i HCl]****ADL-01-0080-0**

5 To a solution of free base **4h** (0.4 g, 0.97 mmol) in 20 mL of absolute alcohol was added 2 ml of hydrazine hydrate and the reaction mixture was stirred at 50°C under a nitrogen atmosphere. Raney<sup>®</sup>nickel (50% slurry in water) was added slowly and the progress of the reaction was monitored on TLC plate [solvent system: CHCl<sub>3</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (99:1:2)]. If needed more of the Raney<sup>®</sup>nickel was added to the reaction mixture. When  
10 reaction was completed, excess of Raney<sup>®</sup>nickel was introduced to decompose the hydrazine hydrate. The reaction mixture was filtered through a celite pad and the pad was washed with hot CH<sub>3</sub>OH. The filtrate was evaporated to dryness. The residue was purified on a silica gel column [solvent system: CHCl<sub>3</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (99:1:2)] and the hydrochloride salt  
15 was prepared from 1M ethereal HCl. Recrystallization from CH<sub>2</sub>Cl<sub>2</sub>:Et<sub>2</sub>O (2:1) gave (±) **5i HCl** as a white solid, 0.2 g (48%); mp 248-250°C (d); <sup>1</sup>H NMR (200 MHz, DMSO-d<sub>6</sub>) δ 1.15-2.18 (m, 12H), 3.00 (s, 3H), 3.15-4.10 (m, 7H), 4.50 (m, 1H), 6.80(d, J = 7.8 Hz, 1H), 6.92 (s, 1H), 7.10 (d, J = 8.0 Hz, 1H), 10.0 (bs, 1H). Anal. Calcd for C<sub>20</sub>H<sub>28</sub>F<sub>3</sub>N<sub>3</sub>O.HCl.0.5H<sub>2</sub>O: C, 56.01; H, 7.05; N, 9.80. Found: C, 55.70; H, 7.03; N, 9.65.

**Example 112****(±)-trans-2-Bismethanesulfonamido-4-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5j HCl]****ADL-01-0118-8**

The compound was prepared from free base (±) **5i** (0.5 g, 1.30 mmol) following the procedure described in the first part of the preparation of (±) **5e**. The bismethanesulfonamide was purified on a silica gel column [solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (96:2:2)]  
30 to give the desired product as a foam. The hydrochloride salt was prepared from 1M ethereal HCl and recrystallized from 2-propanol:Et<sub>2</sub>O (1:1) to give (±) **5j HCl** as a beige colored solid, 0.23 g (30%); mp 224-226°C (d); <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.12-1.51 (m, 4H), 1.53-2.24 (m, 8H), 1.82-3.17 (m, 2H), 2.98 (s, 3H), 3.32-3.56 (m, 2H), 3.28 (s, 3H), 3.33 (s, 3H), 3.77 (m, 1H), 3.97 (d, J = 14.0 Hz, 1H), 4.27 (d, J = 14.0 Hz, 1H), 4.62 (m, 1H), 7.39 (s,  
35 1H), 7.55 (d, J = 8.0 Hz, 1H), 7.85 (d, J = 8.0 Hz, 1H). Anal. Calcd for C<sub>22</sub>H<sub>32</sub>F<sub>3</sub>N<sub>3</sub>O<sub>5</sub>S<sub>2</sub>.HCl: C, 45.87; H, 5.77; N, 7.29. Found: C, 45.53; H, 5.81; N, 7.00.

**Example 113****(±)-trans-2-Methanesulfonamido-4-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5k HCl]****ADL-01-0137-8**

40 To a solution of (±) **5j HCl** (0.16 g, 0.23 mmol) in 9 mL of CH<sub>3</sub>OH:THF (2:1) at room temperature was added 0.12 mL of 10M aqueous NaOH and the mixture was stirred for 30 min. The reaction mixture was neutralized with 1N HCl and evaporated to dryness. The

residue was redissolved in  $\text{CH}_2\text{Cl}_2$  and basified with saturated aqueous solution of  $\text{NaHCO}_3$ . The organic layer was separated, washed with water, saturated salt solution, and dried over anhydrous  $\text{Na}_2\text{SO}_4$ . Removal of solvent under reduced pressure gave the product as a free base. The hydrochloride salt was prepared from 1M etherial HCl and recrystallized from  $\text{CH}_2\text{Cl}_2$ :  $\text{Et}_2\text{O}$  (1:1) to give ( $\pm$ ) **5k HCl** as a beige colored solid, 0.085 g (61%); 209-211°C (d);  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  1.15-1.24 (m, 4H), 1.50-2.10 (m, 8H), 2.20 (m, 2H), 2.90-3.10 (m, 2H), 3.05 (s, 6H), 3.55 (m, 2H), 3.80 (m, 1H), 4.64 (m, 1H), 7.20 (dd,  $J = 7.8$  Hz, 2H), 7.88 (s, 1H), 9.00 (s, 1H). Anal. Calcd for  $\text{C}_{21}\text{H}_{30}\text{F}_3\text{N}_3\text{O}_3\text{S} \cdot \text{HCl} \cdot 0.125 \text{H}_2\text{O}$ : C, 50.42; H, 6.30; N, 8.40. Found: C, 50.62; H, 6.49; N, 8.00.

#### Example 114

##### N-[2-( $\pm$ )-trans-4-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamid]glycine Hydrochloride [( $\pm$ ) **5l HCl**]

ADL-01-0130-3

To a solution of free base ( $\pm$ ) **5i** (0.767, 2.0 mmol) in 10 mL of anhydrous THF under a nitrogen atmosphere at 0°C was added N,N-diisopropylethylamine (Hunig's Base) (1.55 g, 12.0 mmol). The reaction mixture was stirred at 0°C for 15 min then added bromoacetic acid *t*-butyl ester (1.95 g, 10.0 mmol) and the reaction mixture was continued to stir while warming to room temperature 72 h. The solvent was evaporated at reduced pressure and the residue was partitioned between  $\text{CH}_2\text{Cl}_2$  and water. The organic layer was then washed with, saturated  $\text{NaHCO}_3$ , saturated salt solution, and dried over anhydrous  $\text{Na}_2\text{SO}_4$ . Removal of solvent gave the crude product which was purified on a silica gel column [solvent system:  $\text{CHCl}_3$ :  $\text{CH}_3\text{OH}$ : 28%  $\text{NH}_4\text{OH}$  (96:2:2)] to give the intermediate *t*-butyl ester 0.477 g (40%);  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  1.05-1.25 (m, 4H), 1.38-1.90 (m, 8H), 1.40 (s, 9H), 2.15-2.75 (m, 5H), 2.85 (s, 3H), 3.60 (m, 2H), 3.75 (d,  $J = 4.0$  Hz, 2H), 4.45 (m, 1H), 5.85 (m, 1H), 6.55 (s, 1H), 6.80 (d,  $J = 7.5$  Hz, 1H), 7.10 (d,  $J = 7.8$  Hz, 1H).

The above *t*-butyl ester (0.47 g, 0.77 mmol) was suspended in 10 mL of aqueous 4N HCl and added 2-3 drops of anisole. The reaction mixture was stirred at room temperature for 72 h and filtered. The filtrate was evaporated to dryness, redissolved in  $\text{CH}_3\text{CN}$ , filtered again, and concentrated. Addition of the ether gave the product which was filtered, washed with ether, and dried to give ( $\pm$ ) **5l HCl** as a beige colored solid, 0.17 g (41%); mp 178-180°C (d); MS (FAB) 442 (M+1);  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  1.05-2.20 (m, 12H), 2.75 (s, 3H), 2.90-3.25 (m, 5H), 3.30-3.55 (m, 2H), 3.70-4.35 (m, 4H), 4.65 (m, 1H), 6.72 (s, 1H), 6.80 (m, 1H), 6.95 (d,  $J = 7.7$  Hz, 1H). Anal. Calcd for  $\text{C}_{22}\text{H}_{30}\text{F}_3\text{N}_3\text{O}_3 \cdot \text{HCl} \cdot 0.125 \text{Et}_2\text{O}$ : C, 55.47; H, 6.67; N, 8.62. Found: C, 55.64; H, 7.06; N, 9.00.

#### Example 115

##### ( $\pm$ )-trans-3-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [( $\pm$ ) **5m HCl**]

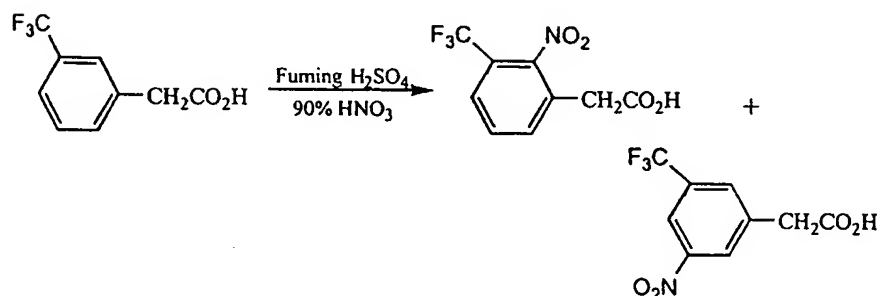
ADL-01-0083-4

Following the Example II, ( $\pm$ ) **5m HCl** was prepared from 3-trifluoromethylphenyl acetic acid in 67% yield as a cream colored solid; mp 245-247°C;  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$

1.15-1.55 (m, 4H), 1.60-2.30 (m, 8H), 2.80-3.05 (m, 2H), 3.00 (s, 3H), 3.18 (m, 1H), 3.45 (m, 1H), 3.75 (d, J = 15.0 Hz, 1H), 3.85 (m, 1H), 4.25 (d, J = 14.8 Hz, 1H), 4.65 (m, 1H), 7.40 (m, 4H). Anal. Calcd for  $C_{20}H_{27}F_3N_2O.HCl.0.25H_2O$ : C, 58.68; H, 7.02; N, 6.84. Found: C, 58.46; H, 7.17; N, 6.69.

5

**Nitration of 3-trifluoromethylphenyl acetic acid :**



10

**Preparation of 2-nitro-3-trifluoromethylphenyl acetic acid [4, R = 2- $NO_2$ (3- $CF_3$ ) -  $C_6H_4CH_2$ ] and preparation of 5-nitro-3-trifluoromethylphenyl acetic acid [4, R = 5- $NO_2$ (3- $CF_3$ ) -  $C_6H_4CH_2$ ]**

15

The nitration of 3-trifluorophenylacetic acid as shown earlier resulted into a 1:1 non-separable mixture of 2- and 5-nitro compounds in 66% yield. The structural assignment of the compounds were made on the basis of  $^1H$  NMR spectrum. The mixture was used in the condensation reaction.

20

**Example 116**

**(±)-trans-5-Nitro-3-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5n HCl] and (±)-trans-2-Nitro-3-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5o HCl]**  
**ADL-01-0087-5 and**  
**ADL-01-0088-3**

25

The compounds were prepared as shown in Example 109 and the mixture of 2- and 5-nitrophenylacetic acids to give the mixture of products. Initially the compounds were separated on a silica gel column [solvent system:  $CHCl_3$ :  $CH_3OH$ : 28%  $NH_4OH$  (96:2:2)] which resulted in the free base of the compounds as pure mixture. The products were again purified on Chromatotran using a 4 mm silica gel plate [solvent system:  $CHCl_3$ , containing 2%  $NH_4OH$ ]. The first product was isolated and converted to the hydrochloride salt and the salt was recrystallized from 2-propanol:ether (1:1) to give (±) 5n HCl as a cream colored solid in 10% yield; mp 236-238°C;  $^1H$  NMR (200 MHz,  $CDCl_3$ )  $\delta$  1.15-1.55 (m, 4H), 1.65-2.30 (m, 8H), 2.85-3.20 (m, 3H), 3.10 (s, 3H), 3.40 (m, 1H), 3.70 (d, J = 14.0 Hz, 1H), 3.85 (m, 1H), 4.60 (brd, 2H), 7.90 (s, 1H), 8.25 (s, 1H), 8.32 (s, 1H). Anal. Calcd for  $C_{20}H_{26}F_3N_3O_3.HCl$ : C, 53.39; H, 6.05; N, 9.34. Found: C, 53.28; H, 6.06; N, 9.36.

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35

The second product, ( $\pm$ ) **5o HCl**, was also isolated in 10% yield after the recrystallization of the hydrochloride salt from 2-propanol:ether (1:1) as a white solid; mp 243-245°C (d);  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  1.10-1.50 (m, 4H), 1.55-2.20 (m, 8H), 2.90-3.20 (m, 3H), 3.10 (s, 3H), 3.44 (m, 1H), 3.65 (d,  $J = 13.5$  Hz, 1H), 3.90 (m, 1H), 4.65 (brd, 2H), 7.70 (s, 1H), 7.82 (s, 2H). Anal. Calcd for  $\text{C}_{20}\text{H}_{26}\text{F}_3\text{N}_3\text{O}_3 \cdot \text{HCl} \cdot \text{H}_2\text{O}$ : C, 51.34; H, 6.25; N, 8.98. Found: C, 51.69; H, 6.24; N, 8.89.

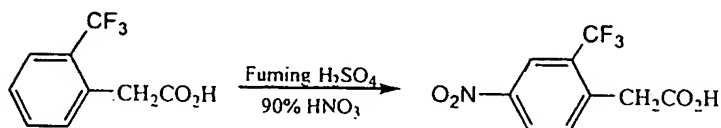
### Example 117

#### 10 ( $\pm$ )-*trans*-2-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [( $\pm$ ) **5p HCl**]

ADL-01-0114-7

The compound was prepared from 2-trifluoromethylphenylacetic acid following the Example II. The hydrochloride salt was made from 1M etherial HCl and recrystallized from 2-propanol:ether (1:1) to give ( $\pm$ ) **5p HCl** in 20% yield as a white solid; mp 282-284°C (d);  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  1.20-1.50 (m, 4H), 1.55-2.30 (m, 8H), 3.85-3.04 (m, 2H), 3.08 (s, 3H), 3.10-3.27 (m, 1H), 3.40-3.60 (m, 1H), 3.90 (m, d,  $J = 14.5$  Hz, 2H), 4.26 (d,  $J = 14.7$  Hz, 1H), 4.63 (m, 1H), 7.26 (t,  $J = 8.0$  Hz, 1H), 7.45 (t,  $J = 8.0$  Hz, 1H), 7.60 (t,  $J = 7.5$  Hz, 2H). Anal. Calcd for  $\text{C}_{20}\text{H}_{27}\text{F}_3\text{N}_2\text{O} \cdot \text{HCl}$ : C, 59.33; H, 6.97; N, 6.92. Found: C, 59.28; H, 6.73; N, 6.84.

#### 25 Nitration of 2-trifluoromethylphenyl acetic acid :



#### 30 Preparation of 4-nitro-2-trifluoromethylphenyl acetic acid [4, R = 4-NO<sub>2</sub>(2-CF<sub>3</sub>) - C<sub>6</sub>H<sub>4</sub>CH<sub>2</sub>]

The nitration of 2-trifluorophenylacetic acid as depicted in Scheme III gave mostly the corresponding 4-nitro derivative and only a trace amount of 6-nitro compound was detected in the proton NMR;  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  3.90 (s, 2H), 7.55 (d,  $J = 8.4$  Hz, 1H), 8.35 (dd,  $J = 2.4, 8.0$  Hz, 1H), 8.50 (d,  $J = 2.4$  Hz, 1H). The compound was used directly into the following coupling reaction.

**Example 118****(±)-trans-4-Nitro-2-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5q HCl]****ADL-01-0116-2**

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The compound was prepared following the coupling method described in Example 109 from 4-nitro-2-trifluorophenylacetic acid. The hydrochloride salt was prepared by known method and recrystallized from 2-propanol:ether (1:1) to give (±) 5q HCl as a beige colored solid in 37% yield; mp 265-267°C (d); <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.15-1.45 (m, 4H), 1.50-2.30 (m, 8H), 2.85-3.20 (m, 3H), 3.05 (s, 3H), 3.45 (m, 1H), 3.90 (m, d, J = 14.0 Hz, 2H), 4.60 (brd, 2H), 8.00 (d, J = 8.0 Hz, 1H), 8.25 (dd, J = 2.4, 8.0 Hz, 1H), 8.40 (d, J = 2.4 Hz, 1H). Anal. Calcd for C<sub>20</sub>H<sub>26</sub>F<sub>3</sub>N<sub>3</sub>O<sub>3</sub>·HCl : C, 53.39; H, 6.05; N, 9.34. Found: C, 53.29; H, 5.93; N, 9.17.

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**Example 119****(±)-trans-4-Amino-2-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide Hydrochloride [(±) 5r 2HCl]**20 **ADL-01-0142-8**

The compound was prepared from free base (±) 5q following the reduction procedure described for the preparation of (±) 5h. The free base was converted to di-hydrochloride from 1M ethereal HCl and recrystallized from CH<sub>2</sub>Cl<sub>2</sub>:CH<sub>3</sub>OH:Et<sub>2</sub>O (6:3:1) to give (±) 5r 2HCl as a white solid in 68% yield; mp 288-290°C (d); <sup>1</sup>H NMR (200 MHz, DMSO-d<sub>6</sub>) δ 1.10-2.20 (m, 12H), 2.98 (s, 3H), 3.00-3.30 (m, 4H), 3.50 (m, 1H), 3.80 (d, J = 14.5 Hz, 1H), 4.20 (d, J = 14.8 Hz, 1H), 4.50 (m, 1H), 7.50 (m, 3H). Anal. Calcd for C<sub>20</sub>H<sub>28</sub>F<sub>3</sub>N<sub>3</sub>O<sub>2</sub>·2HCl : C, 52.64; H, 6.63; N, 9.21. Found: C, 52.67; H, 6.52; N, 9.06.

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**Example 120****(±)-trans-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]2,2-diphenylacetamide Hydrochloride [(±) 5s HCl]**35 **ADL-01-0013-1**

The compound was prepared from diphenylacetic acid following the general procedure for the preparation of aryl acetamides. The hydrochloride salt was recrystallized from 2-propanol to give (±) 5s HCl as a white solid in 20% yield; mp 295-297°C (d); <sup>1</sup>H NMR (200 MHz, CDCl<sub>3</sub>) δ 1.20-2.40 (m, 12H), 2.85-3.15 (m, 2H), 3.00 (s, 3H), 3.25-3.60 (m, 2H), 3.95 (m, 1H), 4.75 (m, 1H), 5.70 (s, 1H), 7.35 (m, 10H). Anal. Calcd for C<sub>25</sub>H<sub>32</sub>N<sub>2</sub>O·HCl·0.25H<sub>2</sub>O : C, 71.92; H, 8.09; N, 6.71. Found: C, 72.25; H, 8.40; N, 6.52.

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**Example 121****(±)-trans-4-Methylsulfonyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]phenylacetamide Hydrochloride [(±) 5t HCl]**

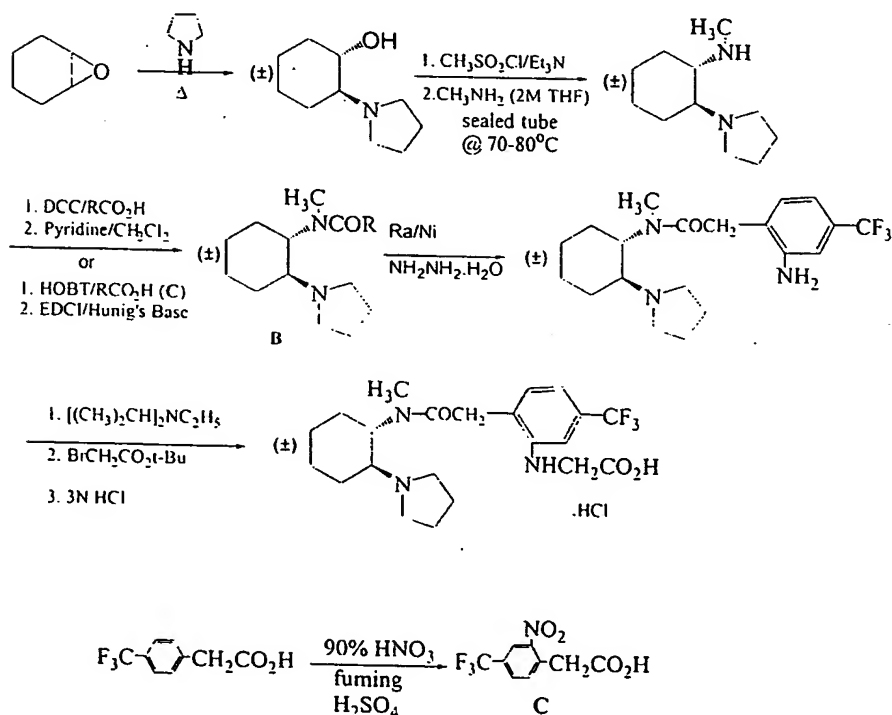
ADL-01-0071-9

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The compound was prepared from 4-methylsulfonylphenylacetic acid to the method of Example 109 and the hydrochloride salt was recrystallized from  $\text{CH}_2\text{Cl}_2:\text{Et}_2\text{O}$  (1:1) to give (±) 5t HCl as a cream colored solid in 50% yield; mp 152-154°C (d);  $^1\text{H}$  NMR (200 MHz,  $\text{CDCl}_3$ )  $\delta$  1.10-2.30 (m, 12H), 2.95 (s, 6H), 3.00-3.25 (m, 2H), 3.40 (m, 1H), 3.65 (d,  $J = 14.5$  Hz, 1H), 3.85 (m, 1H), 4.35 (d,  $J = 14.0$  Hz, 1H), 4.67 (m, 1H), 7.45 (d,  $J = 8.0$  Hz, 2H), 7.80 (d,  $J = 8.0$  Hz, 2H). Anal. Calcd for  $\text{C}_{20}\text{H}_{30}\text{N}_2\text{O}_3\text{S}\cdot\text{HCl}\cdot 1.5\text{H}_2\text{O}$ : C, 54.35; H, 7.75; N, 6.34. Found: C, 54.20; H, 7.38; N, 6.15.

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Preparation of compounds 4a through 41 of formula IVA is according to Scheme O.

**Scheme O**

The chiral compounds were prepared from the enantiomeric pure diamine B

**Example 4a****(Z)-4-[2-((±)-trans-2-Amino-4,5-dichloro-N-methyl-N-[2-(1-pyrrolidinyl)-cyclohexyl]phenylaetamido)]4-oxo-2-butenic acid**

To a solution of (±)-trans-2-amino-4,5-dichloro-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide<sup>3</sup> (0.12 g, 0.312 mmol) in anhydrous THF (2.5 mL) under anitrogen atmosphere was added maleic anhydride (0.03 g, 0.312 mmol). The reaction mixture was stirred at room temperature for 3 days. The precipitated solid was filtered off, washed with anhydrous THF, and dried to give 4a (0.088 g, 58%); mp 246-248°C (d); MS (FAB) 482 (M<sup>+</sup>). Anal. Calcd. for C<sub>23</sub>H<sub>29</sub>Cl<sub>2</sub>N<sub>3</sub>O<sub>4</sub>·H<sub>2</sub>O: C, 55.20; H, 6.24; N, 8.40. Found: C, 55.32; H, 6.01; N, 8.09.

**Ref.**

3. de Costa, B. R. et. al. FEBS Lett. 249, 178-182 (1989).

**Example 4b****(Z)-4-[2-((±)-trans-2-Amino-4-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)-cyclohexyl]-phenylaetamido)]4-oxo-2-butenic acid**

The compound 4b was prepared from (±)-trans-2-amino-4-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)-cyclohexyl]phenylaetamide<sup>1</sup> following the above procedure in 60% yield; mp 256-258°C; <sup>1</sup>H NMR (300 MHz, DMSO-d<sub>6</sub>) δ 1.15 -2.18 (m, 12H), 3.01 (s, 3H), 3.15-4.10 (m, 7H), 4.50 (m, 1H), 5.95 (d, J = 15.0 Hz, 1H), 6.35 (d, J = 14.5 Hz, 1H), 7.37 (m, 2H), 8.16 (s, 1H). Anal. Calcd for C<sub>24</sub>H<sub>30</sub>F<sub>3</sub>N<sub>3</sub>O<sub>4</sub>: C, 59.87; H, 6.28; N, 8.37. Found: C, 59.64; H, 6.14; N, 8.57.

**Example 4c****(±)-trans-2-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-pyridylacetamide dihydrochloride**

The compound 4c was prepared from 2-pyridyl acetic acid hydrochloride and (±)-trans-2-pyrrolidinyl-N-methylcyclohexylamine<sup>3</sup> following the general procedure in 37% yield; mp 264-266°C (d); <sup>1</sup>H NMR (300 MHz, DMSO-d<sub>6</sub>) δ 1.10 -2.00 (m, 12H), 3.04 (s, 3H), 3.15-4.70 (m, 5H), 4.30 (d, J = 16 Hz, 1), 4.55 (m, 1H), 4.67 (d, J = 16.0 Hz, 1H), 7.82 (t, J = 7.5 Hz, 1H), 8.10 (d, J = 7.8 Hz, 1H), 8.55 (t, J = 7.5 Hz, 1H), 8.88 (d, J = 7.0 Hz, 1H). Anal. Calcd for C<sub>18</sub>H<sub>27</sub>N<sub>3</sub>O<sub>2</sub>·2HCl·0.25H<sub>2</sub>O: C, 57.07; H, 7.85; N, 11.09. Found: C, 57.04; H, 7.48; N, 10.69.

**Example 4d****(±)-trans-3-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-5-bromo-pyridylacetamide hydrochloride**

The compound 4d was prepared 5-bromo-3-pyridyl acetic acid in 77% yield; mp 130-132°C; <sup>1</sup>H NMR (free base 200 MHz, CDCl<sub>3</sub>) δ 1.00 -2.00 (m, 12H), 2.88 (s, 3H), 2.35-2.77 (m, 5H),

3.75 (m, 2H), 4.50 (m, 1H), 7.65 (bs, 1H), 8.30 (bs, 1H), 8.67(s, 1H). Anal. Calcd for  $C_{18}H_{26}BrN_3O.HCl$ : C, 51.87; H, 6.53; N, 10.08. Found: C, 51.48; H, 6.11; N, 9.70.

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**Example 4e****(±)-trans-3,5-Di-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]phenylacetamide hydrochloride**

Prepared from 3,5-di-trifluoromethyl-phenyl acetic acid in 27% yield; mp 211-213°C;  $^1H$  NMR (300 MHz,  $CDCl_3$ )  $\delta$  1.20 -2.25 (m, 12H), 3.04 (s, 3H), 3.00-3.35 (m, 3H), 3.50 (m, 1H), 3.80 (d,  $J = 15.0$  Hz, 1H), 4.00 (m, 1H), 4.60 (m, 2H), 7.75 (s, 1H), 7.84 (s, 2H). Anal. Calcd for  $C_{21}H_{26}F_6N_2O.HCl$ : C, 53.34; H, 5.75; N, 5.92. Found: C, 53.14; H, 5.74; N, 5.76.

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**Example 4f****(±)-trans-3-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-(trans-3-furyl)acetamide hydrochloride**

The compound 4f was prepared from trans-3-furan acrylic acid in 56% yield; mp 164-166°C (d);  $^1H$  NMR (200 MHz,  $CDCl_3$ )  $\delta$  1.20 -2.25 (m, 12H), 3.15(s, 3H), 2.75-3.95 (m, 4H), 4.70 (m, 2H), 6.57 (bs, 1H), 6.65 (d,  $J = 15.0$  Hz, 1H), 7.34 (s, 1H), 7.46 (d,  $J = 15.2$  Hz, 1H), 7.55 (s, 1H). Anal. Calcd for  $C_{18}H_{26}N_2O_3.HCl.0.5H_2O$ : C, 62.15; H, 8.11; N, 8.05. Found: C, 61.94; H, 8.01; N, 7.91.

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**Example 4g****(±)-trans-2-Methoxy-3-methylsulfamoyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]phenylacetamide hydrochloride**

The compound 4g was prepared from 2-methoxy-3-methylsulfamoyl-phenyl acetic acid (prepared from methyl 2-methoxy phenyl acetic acid by the procedure reported earlier) in 45% yield; mp 168-170°C;  $^1H$  NMR (200 MHz,  $CDCl_3$ )  $\delta$  1.15 -2.20 (m, 12H), 2.52 (d,  $J = 2.5$  Hz, 3H), 2.76 (s, 3H), 2.40-2.70 (m, 4H), 3.58 (d,  $J = 5.0$  Hz, 1H), 3.79 (s, 3H), 3.84 (d,  $J = 4.8$  Hz, 1H), 4.75 (m, 2H), 6.84 (d,  $J = 8.7$  Hz, 1H), 7.65 (m, 2H). Anal. Calcd for  $C_{21}H_{33}N_3O_4S.HCl.0.5H_2O$ : C, 53.78; H, 7.52; N, 8.96. Found: C, 53.80; H, 7.50; N, 8.90.

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**Example 4h****(±)-trans-3-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]indoleacetamide hydrochloride**

Prepared from indole 3-acetic acid in 61% yield; 262-264°C;  $^1H$  NMR (300 MHz,  $DMSO-d_6$ )  $\delta$  1.20 -2.15 (m, 12H), 2.95 (s, 3H), 2.97-3.55 (m, 4H), 3.83 (s, 2H), 4.55 (m, 2H), 6.96 (t,  $J = 7.5$  Hz, 1H), 7.02 (t,  $J = 7.0$  Hz, 1H), 7.17 (s, 1H), 7.31 (d,  $J = 8.0$  Hz, 1H), 7.57 (d,  $J = 7.8$  Hz, 1H). Anal. Calcd for  $C_{21}H_{29}N_3O.0.9HCl$ : C, 67.75; H, 8.10; N, 11.29. Found: C, 67.78; H, 8.12; N, 11.22.

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**Example 4i****(±)-trans-4-Fluoro-3-methylsulfamoyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]phenylacetamide hydrochloride**

- 5 The compound **4i** was prepared from 4-fluoro-3-methylsulfamoyl phenyl acetic acid in 48% yield; mp 265-267°C; <sup>1</sup>H NMR (200 MHz, DMSO-d<sub>6</sub>) δ 1.30 -2.20 (m, 12H), 2.60 (s, 3H), 3.06 (s, 3H), 3.15-3.80 (m, 4H), 3.91 (d, J = 15.0 Hz, 1H), 4.20 (d, J = 15.5 Hz, 1H), 4.65 (m, 1H), 7.50 (t, J = 8.0 Hz, 1H), 7.75 (m, 2H). Anal. Calcd for C<sub>20</sub>H<sub>30</sub>FN<sub>3</sub>O<sub>3</sub>S.HCl.H<sub>2</sub>O: C, 51.55; H, 7.14; N, 9.02. Found: C, 51.93; H, 6.81; N, 8.70.

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**Example 4j****N-[1*S*, 2*S*-trans-4-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamidol]glycine Hydrochloride**

- 15 **1*S*, 2*S*-trans-2-Nitro-4-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide hydrochloride**

- To a solution of (1*S*, 2*S*)-(+)-trans-2-pyrrolidinyl-N-methylcyclohexylamine<sup>3</sup> (1.9 g, 10.42 mmol) in anhydrous CH<sub>2</sub>Cl<sub>2</sub> (25 mL) under a nitrogen atmosphere was added 2-nitro-4-trifluorophenyl acetic acid<sup>1</sup> (3.9 g, 15.63 mmol) and pyridine (0.42 mL, 5.21 mmol). The reaction mixture was cooled to 0°C and added DCC (4.3 g, 20.84 mmol) in one portion and stirred the mixture for 3.5 h. The TLC [solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (95:5:2)] showed no starting material was present. The DCU was removed by filtration and the solvent was removed under reduced pressure. The residue was partitioned between 10% citric acid (100 mL) and ether (100 mL). The ether layer was discarded and the aqueous layer was washed with ether twice. The aqueous layer was then made alkaline from 28% ammonia hydroxide and the product was extracted with CH<sub>2</sub>Cl<sub>2</sub>. The organic layer was separated, dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>, and evaporated to dryness to give the crude product. The hydrochloride salt was prepared from 1M ethereal HCl and recrystallized from 2-propanol:ether (1:1) to give the desired product, 4.2 g (97%); [α]<sub>D</sub><sup>25</sup> -20.42° (c 1.01, CH<sub>3</sub>OH); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 1.20 -2.35 (m, 12H), 2.98-3.28 (m, 4H), 3.20 (s, 3H), 3.45 (m, 1H), 3.98 (m, 1H), 4.45 (d, J = 14.0 Hz, 1H), 4.70 (d, J = 14.5 Hz, 1H), 7.80 (d, J = 8.7 Hz, 1H), 7.92 (d, J = 8.0 Hz, 1H), 8.34 (s, 1H). The compound was used directly into the following reaction.

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**1*S*, 2*S*-trans-2-Amino-4-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]phenylacetamide hydrochloride**

- The above 2-nitro compound as hydrochloride salt (4.1 g, 9.09 mmol) was dissolved in methanol (30 mL), added PtO<sub>2</sub> (0.4 g), and hydrogenated at room temperature at atmospheric pressure for 1 h. The catalyst was filtered off, washed with hot methanol and the combined filtrate was evaporated to dryness. The residue was re-crystallized from ethyl acetate to give the 2-amino compound as hydrochloride salt, 3.2 g (84%); [α]<sub>D</sub><sup>25</sup> -6.48° (free base, c 0.51, CH<sub>3</sub>OH); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 1.25 -2.35 (m, 12H), 3.00-3.30 (m, 4H), 3.15 (s, 3H), 3.45 (m, 1H), 3.97 (m, 1H), 4.35 (m, 1H), 4.80 (m, 1H), 6.90 (s, d, 2H), 7.05 (d, J = 7.5 Hz, 1H). The free base of the 2-amino compound was used to prepare the target compound.

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The 2-amino compound (free base, 2.8 g, 7.30 mmol) was dissolved in anhydrous THF (20 mL) under a nitrogen atmosphere. N,N-Diisopropylethylamine (1.88 g, 14.60 mmol) was added at room temperature followed by t-butyl bromoacetate (2.14 g, 11.0 mmol) and the reaction mixture was stirred at room temperature for 3 days. The TLC [solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (95:5:2)] showed still starting material was present, the reaction mixture was heated to 60-70°C (oil-bath temperature) for 48 h after the addition of N,N-diisopropylethylamine (1.88 g, 14.60 mmol) and by t-butyl bromoacetate (2.14 g, 11.0 mmol). The reaction mixture was cooled to room temperature and the solvent was removed under reduced pressure. The residue was then re-dissolved in CH<sub>2</sub>Cl<sub>2</sub>, washed with water, 10% aqueous NaHCO<sub>3</sub>, saturated salt solution, and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. Removal of solvent at reduced pressure resulted the crude product which was purified on a silica gel column [solvent system: CH<sub>2</sub>Cl<sub>2</sub>: CH<sub>3</sub>OH: 28% NH<sub>4</sub>OH (98:2:2)] to the desired t-butyl ester, 2.3 g (63%), as a foam; %;  $[\alpha]^{20.5}_{589} -9.5^\circ$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>); the chiral purity (>90%) of the compound was checked on ChiralPak® AD column; MS (FAB) 498 (M+1); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 1.10-2.00 (m, s, 21H), 2.45-2.75 (m, 4H), 2.90 (s, 3H), 3.70 (m, 2H), 3.88 (m, 2H), 4.50 (m, 1H), 6.65 (s, 1H), 6.90 (d, J = 7.0 Hz, 1H), 7.20 (d, J = 7.5 Hz, 1H).

The t-butyl ester (2.1 g, 4.22 mmol) was dissolved in acetic acid (20 mL) and added 4N aqueous HCl (25 mL). After addition of 4 drops of p-anisole, the reaction mixture was stirred at room temperature for 4 days. The solvent was removed under reduced pressure and the residue was re-dissolved in minimum amount of acetonitrile and added excess of ether. The resulting solid was filtered, washed with ether, and dried. Re-crystallization from acetonitrile:ethylacetate (1:1) gave compound 4j (1.0 g, 50%); mp 176-178°C;  $[\alpha]^{20.5}_{589} +6.5^\circ$  (c 0.5, CH<sub>2</sub>Cl<sub>2</sub>); <sup>1</sup>H NMR (300 MHz, DMSO-d<sub>6</sub>) δ 1.10-2.05 (m, s, 12H), 2.70 (s, 3H), 2.98-3.30 (m, 4H), 3.40-4.15 (m, 6H), 6.65 (s, 1H), 6.82 (d, J = 7.5 Hz, 1H), 7.10 (d, J = 7.5 Hz, 1H). Anal. Calcd for C<sub>22</sub>H<sub>30</sub>FN<sub>3</sub>O<sub>3</sub>·HCl: C, 55.29; H, 6.54; N, 8.79. Found: C, 55.61; H, 6.76; N, 8.97.

#### Example 4k

#### N-[1R, 2R-trans-4-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamidol]glycine Hydrochloride

The compound was prepared from (1R, 2R)-(-)-trans-2-pyrrolidinyl-N-methylcyclohexylamine<sup>3</sup> (1.9 g, 10.42 mmol) following the above procedures in 36% yield;  $[\alpha]^{20.5}_{589} -7.4^\circ$  (c 0.52, CH<sub>2</sub>Cl<sub>2</sub>). Anal. Calcd for C<sub>22</sub>H<sub>30</sub>FN<sub>3</sub>O<sub>3</sub>·HCl·0.25 CH<sub>3</sub>CN: C, 55.35; H, 6.55; N, 9.32. Found: C, 55.78; H, 6.81; N, 9.24.

In a composition aspect, the kappa agonist compounds of the present invention are formulated into parenteral, local and topical formulations.

The compositions are formulated as injectables, as oral and rectal formulations for systemic administration, and for local and topical administration as creams, aqueous or non-aqueous suspension, lotions, emulsions, suspensions or emulsions containing micronized particles, gels, foams aerosols, solids and other suitable vehicles for application to the skin,

eyes, lips and mucosa, as suppositories or cream for vaginal administration, and as combinations with bandages, patches, bioadhesives and dressings. The compounds may be formulated in combination with other agents, such as local anesthetics and other therapeutic agents. The other agents may be mixed in the compositions are provided and administered prior to, simultaneously with or subsequent to administration of the compositions provided for the methods herein. Such agents include, but are not limited to: antibiotics, including cephalosporins,  $\beta$ -lactams, tetracyclines, vancomycins, sulfas and aminoglycosides; antivirals, including acyclovir; and antifungals including clotrimazole.

In a method aspect the present invention provides method to treat hyperalgesia by applying an amount of a compound or composition to a mammal to ameliorate or eliminate pain. Thus, the method of the present invention comprises a method of treating pain internally or externally present in the mammalian body including: internal injuries, such as caused by accident or surgical procedures; abnormal functioning of body organs; irritation associated with inflammation following local infection, blisters, boils, or acute skin injuries, such as abrasions, burns, superficial cuts, surgical incisions, toothaches, contusions, irritations, inflammatory skin conditions, including but not limited to poison ivy, and allergic rashes and dermatitis and any condition that yields a hyperalgesic pain state and other such conditions.

#### Assessment of Anti-Hyperalgesic Activity

The pharmacological activity of the compounds of the present invention may be assessed by several art-recognized *in vitro* and *in vivo* models. Some of the typical models are described herein.

##### **(a) In vitro binding assay (Primary Screen)<sup>14</sup>**

The initial test of these compounds is [ $^3\text{H}$ ]diprenorphine binding to the cloned human kappa receptor. The compounds that inhibit binding by at least 80% at 1  $\mu\text{M}$  are titrated and  $K_i$  values are determined by Cheng-Prusoff transformations of  $\text{IC}_{50}$  values. The  $\text{IC}_{50}$  value is the concentration of inhibitor that inhibits binding of radiolabel by 50% and the  $K_i$  value is the affinity of the inhibitor for the receptor. Compounds are also tested against [ $^3\text{H}$ ]U69593 (agonist) binding to this receptor. No compound is known to inhibit only agonist binding or antagonist binding. However, such a compound may have a unique pharmacological profile as a result of its specificity for one region of the receptor.

Initial specificity is determined by testing compounds [ $^3\text{H}$ ]diprenorphine binding to cloned human mu and delta receptors at 10  $\mu\text{M}$  and titrating those compounds that inhibit binding by at least 80%. Compounds that do not have  $K_i$  values at least 100-fold high against

mu and delta receptors may be more likely to have additional side effects and are not pursued to enable further evaluation of specific compounds.

Ref.

- 5 (14) Raynor et al., Mo. Pharmacol. US, 330-334 (1994)

(b) **Inflamed knee joint hyperalgesia model and blood pressure response to compression of the inflamed knee joint**

10 Inflammation in a joint is often associated with hyperalgesia [pain during normal flexion and extension and during the application of gentle innocuous pressure] and/or persistent pain [resting pain; Schaible *et al.* (1993) Pain 55: 5-54]. During the course of knee joint inflammation, a cascade of events occurs, which includes: (i) synthesis and release of inflammatory mediators in the joint, (ii) release of neuropeptides from afferent fibers in the joint cavity, and (iii) increased primary afferent outflow from group II, III, IV sensory fibers  
15 [Schaible *et al.* (1993) Pain 55: 5-54]. An important result of this cascade is that there is an augmentation in the response of small, lightly myelinated and unmyelinated afferents to low intensity stimuli. In this manner, the peripheral nerve innervating inflamed tissue can evoke an exaggerated behavioral response to otherwise innocuous stimuli, *i.e.*, a state of hyperalgesia. Thus, inflammation of the knee joint will result in increased spontaneous  
20 afferent activity, the appearance of an exaggerated discharge with joint flexion and extension [Schaible *et al.* (1995) J. Neurophysiol. 54: 1109-1122] and signs of a pain-associated autonomic reaction [Sata et al (1984) Neurosci. Lett. 52: 55-60].

Injection of a mixture of kaolin and carrageenan into the knee joint induces an experimental arthritis. As exemplified below, this treatment was characterized by a reliable  
25 increase in joint volume and circumference. In the unanesthetized rat, these joint changes were accompanied by a tendency to avoid weight bearing, suggesting an ongoing pain state. According to electrophysiological studies, in the course of the development of this acute arthritis, C and Ad units normally responding only to extreme joint distortion become activated by slight movement [Schaible *et al.* (1985) J. Neurophysiol. 54: 1109-1122]. Spinal  
30 neurons with knee joint receptive fields in the deep dorsal horn of the spinal cord show clear development of hyperexcitability with the acute inflammation in the joint [Neugebauer *et al.* (1993) J. Neurosci. 70: 1365-1377]. This sensitization of group III and IV fibers was observed within 2-3 hours after injection of kaolin and carrageenan into the knee joint, a time course that closely matches the time course of the development of hyperalgesia in the rat knee  
35 joint compression model. These observations indicate that spinal cord neurons and joint primary afferent fibers become sensitized and may underlie hyperalgesia observed in this arthritic state. Such afferent input may drive autonomic responses that are typically associated with the processing of input from afferents typically activated by stimuli generated by the local inflammatory state. In addition to the above-mentioned inflamed knee joint

mechanism, the blood pressure (BP) changes might also be evoked reflexively by afferent neural activity from receptors located in the skeletal muscle [Williamson *et al.* (1994) *J. Physiol.* 475: 351-357]. This response is dependent on the changes in intramuscular pressure and the quality of muscle mass compressed. This particular mechanical reflex, however, appears to operate independently of the pain response and appears to play a minor role in the exemplified experiments, as inflation of the cuff on the left normal knee joint had no effect upon BP. In any case, it is possible that overflow of the carrageenan from the joint capsule may serve to render surrounding tissue inflamed as well. Sensitization of C and A units was observed in the rat gastrocnemius muscle by infiltration with carrageenan [Handwerker *et al.* (1991) *Pain and Inflammation. Proceeding of the VIth World Congress on Pain*, Bond *et al.* eds., Elsevier Science Publishers BV, pp. 59-70]. Based on these considerations, it appears that compression of the inflamed knee joint yields a noxious stimulus and this in turn activates a sympathetic response resulting in an increase in BP.

Local inflammation of the knee results in a state where otherwise innocuous stimuli results in a prominent autonomic response, including increased blood pressure (BP) and heart rate [see, *e.g.*, Sata *et al.* (1984) *Neurosci. Lett.* 52: 55-60]. Alternatively, neural outflow from the inflamed knee is recorded [see, *e.g.* Neugebauer *et al.* (1993) *J. Neurosci.* 70: 1365-1377].

An *in vitro* test that measures spontaneous discharge in injured skin by topical application may also be used. [see, *e.g.*, Andreev *et al.* (1994) *Neurosci.* 58: 793-798].

#### **(c) In vivo evaluation of formalin-induced nociception**

Administration of formalin into the paw results in a localized inflammation and a pain response that is moderate in intensity and continuous in duration. Unlike many other assays of nociception, the formalin assay measures tonic pain that is a result of tissue injury, and therefore is a model which is more relevant to clinical pain states in humans [see Tjolsen *et al.* (1992) *Pain* 51: 5-17]. In the rat the response to formalin-induced pain consists of spontaneous flinching behavior, characterized by paw lifting and paw shaking, and a rapid vibration of the paw after drawing it under the body. The flinching response can be reliably quantitated and exhibits two peaks of activity which are indicative of acute and tonic pain [Wheeler-Aceto and Cowan (1991) *Psychopharmacology* 104: 35-44]. The early or acute phase lasts from 0-5 min post-formalin and is followed by a quiescent period lasting approximately 15 min. The tonic phase occurs from 20-35 min following formalin injection and is the interval where the number of flinching responses is maximal. This model has been characterized in several species [Tjolsen *et al.* (1992) *Pain* 51: 5-17] and is sensitive to the analgesic effects of opiates administered by a variety of routes, including local administration directly into the paw. In addition, the test is particularly sensitive to the effects of  $\kappa$  agonists [Wheeler-Aceto and Cowan (1991) *Psychopharmacology* 104: 35-44].

Inflammation is induced by subcutaneous injection of 50  $\mu$ l of a 5% formalin solution into the dorsal surface of the right hind paw of male Sprague-Dawley rats weighing 70-90 g.

5 Injections of drug are given into the dorsal surface of the paw prior to formalin injection, and flinching behavior is quantitated by counting the number of responses that occur during the tonic phase of pain, lasting from 20-35 min after formalin injection. Results are expressed as the mean percent antagonism of formalin-induced flinching calculated for individual drug-treated, formalin-injected rats using the following formula:

$$\frac{(\text{mean formalin response} - \text{mean saline response}) - \text{individual response}}{\text{mean formalin response} - \text{mean saline response}} \times 100$$

10 The mean formalin response is the mean behavioral score of vehicle-treated and formalin-injected rats. The mean saline response is the pooled behavioral score from rats injected with 50 ml of saline into the paw.

**(d) Randall-Selitto Test**

Numerous variations and exemplifications of this assay are known to those of skill in this art [see, Randall et al (1957) Arch. Int. Pharmacodyn. 111: 409-419; see, also, e.g., U.S. Patent No. 5,434,292, U.S. Patent No. 5,369,131, U.S. Patent No. 5,345,943, U.S. Patent No. 5,242,944 and U.S. Patent No. 5,109,135.

The pain threshold is measured in this method as the amount of pressure in g required to induce a flight reaction (struggle) when applied to the foot of an experimental animal exhibiting hyperalgesia, typically an inflamed paw, compared to a control, such as the same or equivalent animal in the absence of the inflammation, and/or in the absence of a test compound. Incremental pressure is applied to the paw with a wedge-shaped blunt piston onto the dorsal surface of the hind paw by means of a paw pressure analgesia meter. The pressure required to elicit paw withdrawal, the paw pressure threshold (PPT), is determined.

25 Stein and coworkers [Stein *et al.* (1988) Pharmacol. Biochem. Behav. 31: 445-451; Stein *et al.* (1989) J. Pharmacol. Exp. Ther. 248: 1269-1275] have developed a model of peripheral inflammation and hyperalgesia in rats, which supports the role of opiates in mediating peripheral analgesia. In this protocol, modified Freund's adjuvant is used as the inflammatory stimulus, and the paw pressure test is used to assess the response of the rat to a painful pressure stimulus. The model is sensitive to opiate agonists of the m, d and k subtypes, which produce analgesia upon administration [Antonijevic *et al.* (1995) J. Neurosci. 15: 165-172; Stein *et al.* (1988) Neurosci. Lett. 84: 225-228; Stein *et al.* (1989) J. Pharmacol. Exp. Ther. 248: 1269-1275]. Histological verification of opiate receptor localization and density have confirmed that peripheral opiate receptors are accessible on primary afferent nerve fibers and are upregulated following inflammation [Hassan *et al.* (1993) Neuroscience 55: 185-193; Przewlocki *et al.* (1992) Neuroscience 48: 491-500].

35 Experiments are conducted in rats weighing 150-250 g at the time of inoculation. Modified Freund's complete adjuvant (FCA) is used as the inflammatory stimulus. Rats are

administered an i.pl. injection of the FCA suspension into the right hind foot. Hyperalgesia and antinociception are evaluated using the paw pressure test. The rat is gently restrained and incremental pressure is applied to the paw with a wedge-shaped blunt piston onto the dorsal surface of the hind paw by means of a paw pressure analgesia meter. The pressure required to elicit paw withdrawal, the paw pressure threshold (PPT), is determined. A cutoff pressure of 250 g is used to avoid undue stress and pain to the animal. Baseline responding is established by determining the average of three consecutive trials separated by 10 sec. The same procedure is conducted on the contralateral side and the sequence of sides is alternated between animals to control for order effects. Typically injections are not made in the contralateral (noninflamed) paw; however, in selected cases drugs may be administered to the contralateral paw to evaluate the potential for drug effects in the absence of inflammation.

Analgesic activity is determined by expressing the increase in PPT resulting from the effect of the drug as a percentage of basal preinjection thresholds.

Hyperalgesia can also be produced by inflammatory stimuli such as yeast or carrageenan, endogenous inflammatory mediators such as bradykinin or prostaglandins, or other types of chemical irritants [see Hargreaves and Joris (1993) APS Journal 2: 51-59].

**(e) Acetic acid-induced writhing**

This test identifies novel agents which exhibit peripheral analgesic activity against visceral or chemical pain [see Barber and Gottschlich (1986) Med. Res. Rev. 12: 525-562; Ramabadran and Bansinath (1986) Pharm. Res. 3: 263-270]. Injection of acetic acid into the peritoneal cavity is used as the noxious stimulus, and the number of writhing responses that occur in response to acetic acid are counted in order to quantify the response to pain. Compounds which possess analgesic activity reduce the number of writhing responses that occur. Opiate agonists of the m and k subtype exhibit analgesic activity in this model [Barber and Gottschlich (1986) Med. Res. Rev. 12: 525-562; Millan (1990) Trends Pharmacol. Sci. 11: 70-76]. Novel compounds which demonstrate potency and efficacy in this assay are potential drugs for the treatment of various pathological conditions involving peripheral pain.

The writhing assay is adapted from the procedure originally described by Taber *et al.* [(1969) J. Pharmacol. Exp. Ther. 169: 29-38], using male CF-1 mice weighing 20-25 g. Animals are treated with various doses of drugs prior to the administration of an i.p. injection of 0.6% acetic acid solution. Mice are then placed into observation chambers and the number of writhing responses, as defined by a full hindlimb extension and retraction, are recorded.

The mean number of writhing responses is calculated for vehicle-treated control mice, and the percent inhibition (% I) of writhing is calculated for each mouse that is treated with drug using the following formula:

$$\% I = 100 \times \frac{(\text{mean control writhing responses} - \text{individual test responses})}{\text{mean control writhing responses}}$$

(f) **Hyperalgesia induced by tape stripping**

The objective of this assay is to identify novel agents which exhibit peripherally-mediated analgesia in circumstances, such as burns and abrasions, which lead to hyperalgesia. In such injuries, the loss of the stratum corneum is followed by an inflammatory response (erythema) and a painful response to otherwise innocuous stimuli. Removal of the stratum corneum by repeated application and removal of cellophane tape, termed tape stripping, has been shown to be a simplified model of these injuries, which share characteristics of first degree burns [see Flynn (1985) Percutaneous Absorption, R.L. Bronaugh and H.I. Maibach, eds., Marcel Dekker Inc., pp. 18-42]. This method of barrier disruption avoids the application of potentially toxic chemicals and permits evaluation of peripheral analgesics following topical administration because tape stripping removes the barrier to effective topical therapy (the stratum corneum) while simultaneously resulting in inflammation and hyperalgesia. Tape stripping has been validated in humans as a model for the testing of topical agents [Pershing *et al.* (1994) *Antimicrob. Agents Chemother.* 38: 90-95; Roy and Flynn (1990) *Pharm. Res.* 7: 842-847].

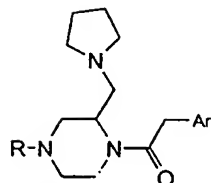
Experiments are conducted in male Sprague-Dawley rats weighing 250-500 g at the time of treatment. After anesthesia of the rat with ketamine-xylamine, a 1-3 cm<sup>2</sup> patch of rat skin is treated by repeated application and removal of tape. This procedure results in removal of the stratum corneum as determined by a glistening appearance of the skin. The tape stripped skin is evaluated for a visible erythema and for sensitivity to contact by heat or pressure stimuli using a focused beam of light, by testing in the paw pressure apparatus or by touch with von Frey hairs. The diameter of the von Frey hairs will be selected based on a diameter which causes no response in control rats but has a readily detectable response in treated rats.

Typically analgesics will be formulated in a suitable topical medium and applied to the treated skin. Some rats will receive only the topical medium without analgesic to control for an effect of the topical medium alone. The presence of analgesia is determined by the latency to respond to the heat stimulus or by response to touch or pressure.

Pharmacological activities of compounds of the present invention are shown in Tables I, IA, II, IIA, III, IIIA, IV and IVA in which K<sub>i</sub>: nM (<sup>3</sup>H-diprenorphin and <sup>3</sup>H-U-69, 593) show in vitro binding assay results as described in "(a) In vitro binding assay (Primary Screen); and A<sub>50</sub> (μg); i.paw show in vivo formalin-induced nociception results as described in "(c) In vivo evaluation of formalin-induced nociception".



**TABLE I**  
**Compounds of Formula I**



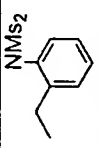
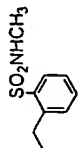
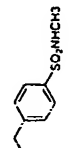
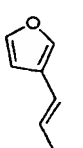
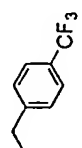
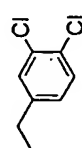
*R*-3a-l  
*R,S*-8a-e, *R* = SO<sub>2</sub>CH<sub>3</sub>  
*R,S*-9a-f, *R* = CO<sub>2</sub>CH<sub>3</sub>  
*R,S*-10a-f, *R* = COCH<sub>3</sub>

5

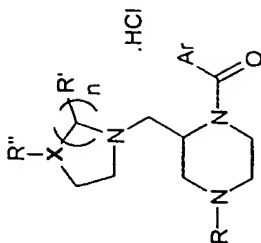
Compounds	R	Ar	Ki, nM		Late Phase Formalin A <sub>50</sub> (mg);i.paw
			<sup>3</sup> H-Diprenorphin	<sup>3</sup> H-U-69,593	
GR 89696 ( <i>R</i> )	CO <sub>2</sub> CH <sub>3</sub>	3,4 - Cl <sub>2</sub>	0.095, 0.10	1.6, 1.5	0.35(0.20-0.62)
ADL-01-0143-6 ( <i>R</i> -1)	Bn	3,4 - Cl <sub>2</sub>	57, 38	9.3	53% @ 300
ADL-01-0047-9 ( <i>R</i> -2)	H	3,4 - Cl <sub>2</sub>	14, 17	1.5, 1.3	57% @ 300
ADL-01-0039-6 ( <i>R</i> -3a)	SO <sub>2</sub> CH <sub>3</sub>	3,4 - Cl <sub>2</sub>	0.2, 1.3	0.19, 0.5	14 (5.6-29)
ADL-01-0040-4 ( <i>R</i> -3b)	CH <sub>2</sub> CO <sub>2</sub> t-Bu	3,4 - Cl <sub>2</sub>	30% @ 1uM	75% @ 1uM	75% I @ 1 μM
ADL-01-0042-0 ( <i>R</i> -3c)	CH <sub>2</sub> CO <sub>2</sub> H	3,4 - Cl <sub>2</sub>	62% @ 1uM	23, 21	26% @ 300
ADL-01-0048-7 ( <i>R</i> -3d)		3,4 - Cl <sub>2</sub>	36% @ 1uM	379, 249	Not tested.
ADL-01-0041-2 ( <i>R</i> -3e)		3,4 - Cl <sub>2</sub>	39% @ 1uM	37, 28	22% A @ 300
ADL-01-0148-5 ( <i>R</i> -3f)	COCH <sub>3</sub>	3,4 - Cl <sub>2</sub>	4.2, 1.4	0.11, 0.14	95% @ 300
ADL-01-0149-3 ( <i>R</i> -3g)	PO(OEt) <sub>2</sub>	3,4 - Cl <sub>2</sub>	99, 33	1.3, 1.4	54% @ 300
ADL-01-0150-1 ( <i>R</i> -3h)	COCF <sub>3</sub>	3,4 - Cl <sub>2</sub>	6.9, 1.8	0.26, 0.16	94% @ 300

Compounds	R	Ar	Ki, nM		Late Phase Formalin A <sub>50</sub> (mg);i.paw
			<sup>3</sup> H-Diprenorphin	<sup>3</sup> H-U-69,593	
ADL-01-0151-9 (R-3i)	CONH <sub>2</sub>	3,4 - Cl <sub>2</sub>	56, 29	2.9	68% @ 300
ADL-01-0156-8 (R-3j)	CHO	3,4 - Cl <sub>2</sub>	96% @ 1uM	0.40	65% @ 300
ADL-01-0165-9 (R-3l)	SO <sub>2</sub> -Tol	3,4 - Cl <sub>2</sub>	120	6.2	24% @ 300
ADL-01-0135-2 (R,S-8a)	SO <sub>2</sub> CH <sub>3</sub>	3,4 - Cl <sub>2</sub>	5.4, 4.0	0.37, 0.65	96% @ 300
ADL-01-0117-0 (R,S-8b)	SO <sub>2</sub> CH <sub>3</sub>	p-SO <sub>2</sub> CH <sub>3</sub>	41% @ 1uM	20, 31	Not tested
ADL-01-0119-6 (R,S-8c)	SO <sub>2</sub> CH <sub>3</sub>	o-NO <sub>2</sub>	15% @ 1uM	51% @ 1uM	Not tested
ADL-01-0120-4 (R,S-8d)	SO <sub>2</sub> CH <sub>3</sub>	p-CF <sub>3</sub>	16, 17	1.3, 1.9	97% @ 300
ADL-01-0134-5 (R,S-8e)	SO <sub>2</sub> CH <sub>3</sub>	3-indole	74%	5.3, 3.2	Not tested
ADL-01-0092-5 (R,S-9a)	CO <sub>2</sub> CH <sub>3</sub>	p-SO <sub>2</sub> CH <sub>3</sub>	11	0.37, 0.42	46% @ 300
ADL-01-0094-1 (R,S-9b)	CO <sub>2</sub> CH <sub>3</sub>	p-CF <sub>3</sub>	0.49	0.076, 0.13	98% @ 300
ADL-01-0095-8 (R,S-9c)	CO <sub>2</sub> CH <sub>3</sub>	3-indole	3.0	0.27, 0.40	95% @ 300
ADL-01-0096-6 (R,S-9d)	CO <sub>2</sub> CH <sub>3</sub>	o-NO <sub>2</sub>	37	0.74, 0.73	93% @ 300
ADL-01-0097-4 (R,S-9e)	CO <sub>2</sub> CH <sub>3</sub>	o-OCH <sub>3</sub>	7.3	0.46, 1.3	98% @ 300
ADL-01-0098-2 (R,S-9f)	CO <sub>2</sub> CH <sub>3</sub>	o-NH <sub>2</sub>	4.6, 3.2	0.67, 0.41	97% @ 300
ADL-01-0144-4 (R,S-10a)	COCH <sub>3</sub>	p-SO <sub>2</sub> CH <sub>3</sub>	27%	2.3	6% @ 300

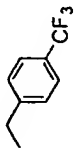
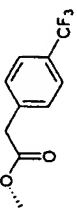
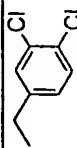
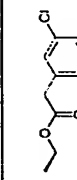
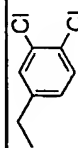

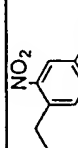

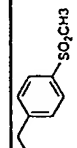
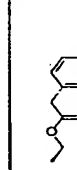
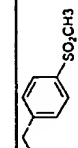

ADL-01-0145-1 (R,S-10b)	COCH <sub>3</sub>	p-CF <sub>3</sub>	26, 24	2.0	89% @ 300
ADL-01-0157-6 (R,S-10c)	COCH <sub>3</sub>	o-CF <sub>3</sub>	45% @ 1uM	16	Not tested
ADL-01-0158-4 (R,S-10d)	COCH <sub>3</sub>	m-NO <sub>2</sub>	94% @ 1uM	0.72	Not tested
ADL-01-0163-4 (R,S-10e)	COCH <sub>3</sub>	o-NO <sub>2</sub>	541	24	Not tested
ADL-01-0159-2 (R,S-10f)	COCH <sub>3</sub>	p-NO <sub>2</sub>	59% @ 1uM	2.4	Not tested
ADL-01-0093-3 (R,S-11)	Bn	p-CF <sub>3</sub>	2.2, 2.4	0.39, 0.57	92% @ 300

	R	Ar	R'	R''	n	X	Ki(nM) ( <sup>3</sup> H)-Diprenorphin	Formalin (%A@300mM) i. paw or A <sub>50</sub> mg/kg s.c.
1d	CO <sub>2</sub> CH <sub>3</sub>		H	H	1	CH <sub>2</sub>	7.6	77%@300
1e	CO <sub>2</sub> CH <sub>3</sub>		H	H	1	CH <sub>2</sub>	14	55%@300
1f	CO <sub>2</sub> CH <sub>3</sub>		H	H	1	CH <sub>2</sub>	53.5	Not tested
1g	COCF <sub>3</sub>		H	H	1	CH <sub>3</sub>	5%@1mM	Not tested
1h	COCF <sub>3</sub>		H	H	1	CH <sub>2</sub>	50	100%@300
1i	CO <sub>2</sub> CH <sub>3</sub>		H	CO <sub>2</sub> CH <sub>3</sub>	2	N	12%@1mM	Not tested

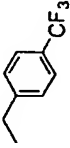
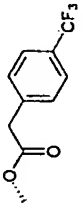
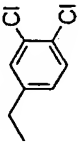
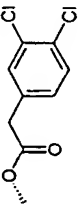
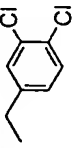
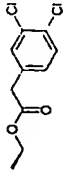
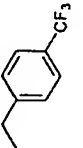
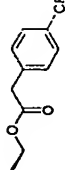
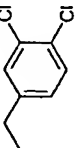
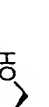
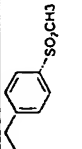
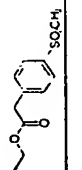
**TABLE IA**  
**Compounds of Formula IA**



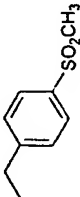

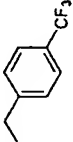

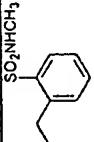

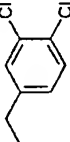
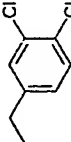
	R	Ar	R'	R''	n	X	K <sub>i</sub> (nM) ( <sup>3</sup> H)-Diprenorphin	Formalin (%A@300mM) i. paw or A <sub>50</sub> mg/kg s.c.
1a	CO <sub>2</sub> CH <sub>3</sub>		H	H	1	CH <sub>2</sub>	248	Not tested
1b	CO <sub>2</sub> CH <sub>3</sub>		H	H	1	CH <sub>2</sub>	7	Not tested
1c	CO <sub>2</sub> CH <sub>3</sub>		H	H	1	CH <sub>2</sub>	65%@1mM	69%@300

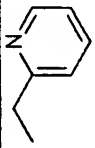
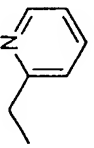
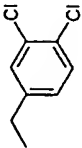

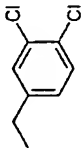
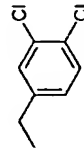
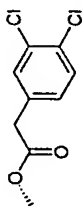
	R	Ar	R'	R''	n	X	Ki(nM) ( <sup>3</sup> H)-Diprenorphin	Formalin (%A@300mM) i. paw or A <sub>50</sub> mg/kg s.c.
Ij	CO <sub>2</sub> CH <sub>3</sub>		H		1	CH	13	Not tested
Ik	CO <sub>2</sub> CH <sub>3</sub>			H	1	CH	51.5	95%@300
Il (R,S)	CO <sub>2</sub> CH <sub>3</sub>			H	1	CH	3.5	1.7
Im	CO <sub>2</sub> CH <sub>3</sub>			H	1	CH	49.5	1.7
In	CO <sub>2</sub> CH <sub>3</sub>			H	1	CH	12%@1mM	Not tested
Io	CO <sub>2</sub> CH <sub>3</sub>			H	1	CH	133	41%@300

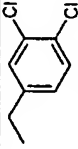
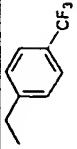
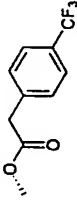
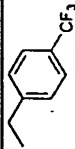
	R	Ar	R'	R''	n	X	Ki(nM) ( <sup>3</sup> H)-Diprenorphin	Formalin (%A@300mM) i. paw or A <sub>50</sub> mg/kg s.c.
Ip	CO <sub>2</sub> CH <sub>3</sub>			H	1	CH	11	Not tested
Iq	CO <sub>2</sub> CH <sub>3</sub>		H		1	CH	5.2	98%@300
Ir	COCH <sub>3</sub>		H	H	1	CH	43%@1mM	Not tested
Is	COCH <sub>3</sub>		H	H	1	CH	53%@1mM	Not tested
Ii	COCH <sub>3</sub>		H	H	1	CH	1%@1mM	Not tested
Iu	COCH <sub>3</sub>		H		1	CH	1780	Not tested

	R	Ar	R'	R''	n	X	Ki(nM) ( <sup>3</sup> H)-Diprenorphin	Formalin (%A@300mM) i. paw or A <sub>50</sub> mg/kg s.c.
Iv	COCH <sub>3</sub>		H		1	CH	4.3	70%@300
Iw	COCH <sub>3</sub>		H		1	CH	1156	60%@300
Ix	COCH <sub>3</sub>			H	1	CH	36%@1mM	Not tested
Iy	COCH <sub>3</sub>			H	1	CH	45%@1mM	Not tested
Iz	COCH <sub>3</sub>			H	1	CH	102	71%@300
Iaa	COCH <sub>3</sub>			H	1	CH	%@1mM	Not tested

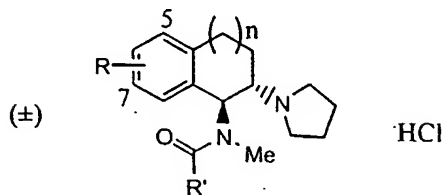


	R	Ar	R'	R''	n	X	Ki(nM) ( <sup>3</sup> H)-Diprenorphin	Formalin (%A@300mM) i. paw or A <sub>50</sub> mg/kg s.c.
1hb	COCH <sub>3</sub>			H	1	CH	11%@1mM	46%@300
1cc	COCH <sub>3</sub>			H	1	CH	22%@1mM	10%@300
1dd	CHO		H	H	1	CH	13%@1mM	Not tested
1ee			H	H	1	CH	58.9	1.0
1ff	allyl		H	H	1	CH	0.58	98%@300

	R	Ar	R'	R''	n	X	Ki(nM) ( <sup>3</sup> H)-Diprenorphin	Formalin (%A@300mM) i. paw or A <sub>50</sub> mg/kg s.c.
lgg	COCH <sub>3</sub>		H	H	1	CH	27%@1mM	Not tested
lhh	CHO		H	H	1	CH	0%@1mM	Not tested
lii (S,S)	CO <sub>2</sub> CH <sub>3</sub>			H	1	CH	21.5	60%@300
ljij	SO <sub>2</sub> CH <sub>3</sub>		H	...OMs	1	CH	11.5	49%@300
lkk	SO <sub>2</sub> CH <sub>3</sub>		H		1	CH	5.1	52%@300

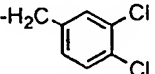
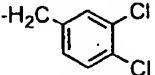
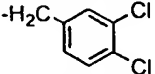
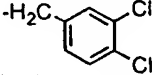
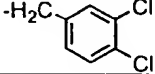
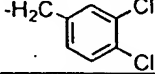
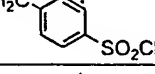
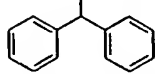
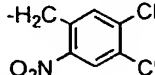
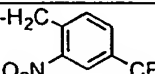
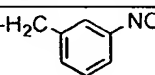
	R	Ar	R'	R''	n	X	Ki(nM) ( <sup>3</sup> H)-Diprenorphin	Formalin (%A@300mM) i. paw or A <sub>50</sub> mg/kg s.c.
III	SO <sub>2</sub> CH <sub>3</sub>		H	.....OH	1	CH	2.86	52%@300
I <sub>mm</sub>	SO <sub>2</sub> CH <sub>3</sub>		H		1	CH	287	Not tested
I <sub>nn</sub>	SO <sub>2</sub> CH <sub>3</sub>		H	.....OH	1	CH	2.33	7.1

**TABLE II**  
**Compounds of Formula II**

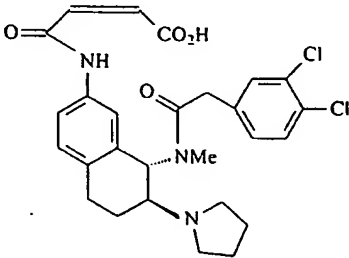


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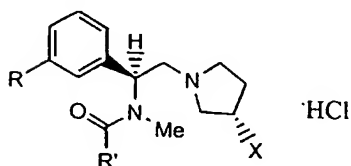
Compounds	R, n	R'	K <sub>i</sub> (nM) k [ <sup>3</sup> H] Diprenorphin	K <sub>i</sub> (nM) k [ <sup>3</sup> H]U69,593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0017-2	7-OCH <sub>3</sub> , n=1		4.7	0.8	44% A @300
ADL-01-0020-6	7-OCH <sub>3</sub> , n=1		142	20	124
ADL-01-0018-0	7-OH, n=1		0.6	0.18	7
ADL-01-0021-4	7-OH, n=1		549	432	Not tested
ADL-01-0019-8	7-OCH <sub>2</sub> CO <sub>2</sub> H, n=1		40	7	39% @ 300
ADL-01-0029-7	7-NO <sub>2</sub> , n=1		2.8	0.8	65
ADL-01-0034-7	7-NO <sub>2</sub> , n=1		57% @ 1 mM	12.8	40% A @ 300
ADL-01-0031-3	7-NO <sub>2</sub> , n=1		9.6	0.7	891
ADL-01-0032-1	7-NH <sub>2</sub> , n=1		2.2	0.35	19
ADL-01-0052-9	7-N(CH <sub>2</sub> CO <sub>2</sub> Et) <sub>2</sub> , n=1		4.6	0.68	37% A @ 300
ADL-01-0037-0	7-N(CH <sub>2</sub> CO <sub>2</sub> tBu) <sub>2</sub> , n=1		7.4	2.8 nM	155
ADL-01-0044-6	7-N(CH <sub>2</sub> CO <sub>2</sub> H) <sub>2</sub> , n=1		3.8	0.68	232

Compounds	R, n	R'	K <sub>i</sub> (nM) k [ <sup>3</sup> H] Diprenorphin	K <sub>i</sub> (nM) k [ <sup>3</sup> H]U69.593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0070-1	7-NH(CH <sub>2</sub> ) <sub>n</sub> PO <sub>3</sub> Et <sub>2</sub> , n=1		6.2	2.2	Not tested
ADL-01-0053-7	7-NHPO <sub>3</sub> Et <sub>2</sub> , n=1		2.4	0.6	34
ADL-01-0090-9	7-SO <sub>2</sub> NCH <sub>2</sub> Bn, n=1 6-OMe		48	8.0	Not tested
ADL-01-0099-0	7-SO <sub>2</sub> NCH <sub>2</sub> Bn, n=1		200	40	Not tested
ADL-01-0051-1	-H, n=2		8.4	2.8	21% A @ 300
ADL-01-0107-1	R=H, n=0		12	2.0	80% @ 300
ADL-01-0109-7	R=H, n=0		46% @ 1 mM	29	Not tested
ADL-01-0108-9	R=H, n=0		29% @ 1 mM	146	Not tested
ADL-01-0104-8	R=H, n=0		5.7	0.74	Not tested
ADL-01-0106-3	R=H, n=0		75% @ 1 mM	9	Not tested
ADL-01-0105-5 (±)-Niravoline	R=H, n=0		13	1.8	92% @ 300

**Table IIA**  
**Compound of Formula IIA**

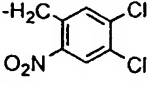
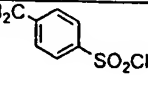
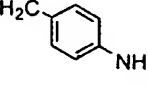
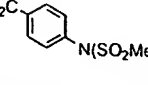
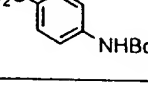
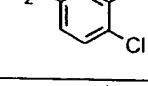
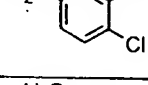
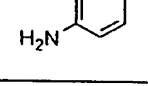
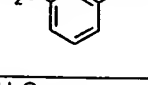
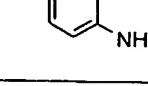
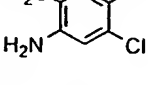
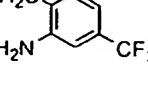
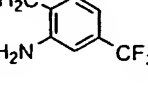
Compound	Structure	$K_i$ (nM) [ $^3H$ ] Diprenorphin $\kappa$	Late Phase Formalin
2a		28.0	69% @ 300 $\mu$ g

**Table III**  
**Compounds of Formula III**



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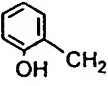

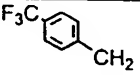
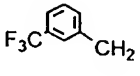
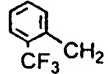
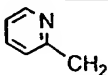
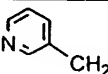
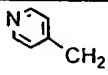
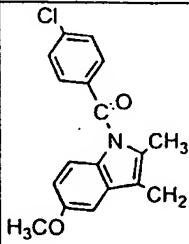
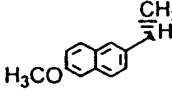
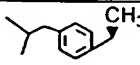
Compounds	X	R	R'	K <sub>i</sub> (nM) k [ <sup>3</sup> H]Diprenorphin	K <sub>i</sub> (nM) k [ <sup>3</sup> H]U69,593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0004-0	-H	-NO <sub>2</sub> (3-5% p-NO <sub>2</sub> )		0.65	0.25	16
ADL-01-0030-5	-H	-H		2.9, 9.0	0.7, 1.0	29
ADL-01-0055-2	OH	R=H		0.61	0.085	15
ADL-01-0033-9	-H	-H		0.2	0.1	5.3
ADL-01-0056-0	OH	R=H		0.09	0.07	2.7mg/ms (i-paw) 0.18 mg/kg (sc)
ADL-01-0062-8	-H	-H		0.20	0.26	27
ADL-01-0067-7	OH	R=H		0.16	0.11	97% @ 300
ADL-01-0084-2	-H	-H		0.28	0.08	95% A @ 300
ADL-01-0079-2	-H	-H		24% @ 1 mM	1.35	Not tested
ADL-01-0115-4	-H	-NO <sub>2</sub>		35	3.2	Not tested

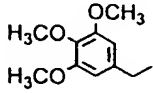
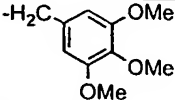
Compounds	X	R	R'	K <sub>i</sub> (nM) k [ <sup>3</sup> H]Diprenorphin	K <sub>i</sub> (nM) k [ <sup>3</sup> H]U69,593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0128-7	-H	-NO <sub>2</sub>		0.3	0.07	Not tested
ADL-01-0129-5	-H	-NO <sub>2</sub>		31	1.5	Not tested
ADL-01-0132-9	-H	-NO <sub>2</sub>		76% @ 1mM	6.4	Not tested
ADL-01-0133-7	-H	-NO <sub>2</sub>		25% @ 1mM	79% @ 1mM	Not tested
ADL-01-0138-6	-H	-NO <sub>2</sub>		19% @ 1 mM	168	Not tested
ADL-01-0005-7	-H	2,3-Br <sub>2</sub> 4-NH <sub>2</sub>		9.4	4.25	306
ADL-01-0007-3	-H	-NH <sub>2</sub>		0.14	0.04	0.4
ADL-01-0024-8	-H	-H		8.15	1.45	65
ADL-01-0089-1	-H	-H		13	0.85	58% @ 300
ADL-01-0103-0	-H	-H		22	1.8	52% @ 300
ADL-01-0035-4	-H	-H		0.10	0.055	7
ADL-01-0068-5	-H	-H		0.09	0.10	0.02 mg/Kg(s.c.)
ADL-01-0076-8	-OH	R=H		0.18	0.12	0.02 mg/kg sc



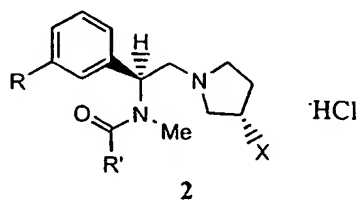
Compounds	X	R	R'	K <sub>i</sub> (nM) k [ <sup>3</sup> H]Diprenorphin	K <sub>i</sub> (nM) k [ <sup>3</sup> H]U69,593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0113-9	-H	-NH <sub>2</sub>		20	2.6	81% @ 300
ADL-01-0059-0 (EMD 60400)	-OH	R=H		0.8	0.175	33
ADL-01-0136-0	-H	-NH <sub>2</sub>		61% @ 1 mM	43	Not tested
ADL-01-0008-1	-H	NH-a-D-Asp		3.65	1.05	72
ADL-01-0009-9	-H	NH-a-L-Asp		1.9	0.5	9.1
ADL-01-0010-7	-H	NH-a-L-(Asp) <sub>2</sub>		2.0	0.67	14
ADL-01-0006-5	-H	NH-b-L-Asp		2.3	0.7	47
ADL-03-1066	-H	NH-g-D-Glu				62
ADL-01-0011-5	-H	-N(SO <sub>2</sub> Me) <sub>2</sub>		6.45	1.2	58
ADL-01-0060-2	-H	-H		57% @1mM	6.4, 8.9	17
ADL-01-0075-0	-H	-H		54, 40	6.8, 3.5	8.8 mg/Kg (s.c.)
ADL-01-0050-3	-H	-H		0.38, 0.45	0.01, 0.09	28
ADL-01-0069-3	-H	-H		0.83, 0.49	0.29, 0.43	Not tested

Compounds	X	R	R'	K <sub>i</sub> (nM) k [ <sup>3</sup> H]Diprenorphin	K <sub>i</sub> (nM) k [ <sup>3</sup> H]U69,593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0077-6	-H	-H		2.2, 3.8	0.64, 0.38	Not tested
ADL-01-0112-1	-H	-H		63% at 1 mM	10.8	91% @ 300
ADL-01-0127-9	-H	-H		198	32	Not tested
ADL-01-0126-1	-H	-N(SO <sub>2</sub> Me) <sub>2</sub>		7% @ 1 mM	58% @ 1 mM	Not tested
ADL-01-0124-6	-H	-NHPO <sub>3</sub> Et <sub>2</sub>		33	48	Not tested
ADL-01-0139-4	-H	-NHPO <sub>3</sub> Et <sub>2</sub>		56% @ 1 mM	76	Not tested
ADL-01-0063-6 (EMD 61753)	-OH	R=H		0.52	0.34	59 mg/rms (i-paw) 28 mg/kg (sc)
ADL-01-0023-0	-H	-H		25, 18	4.8, 3.0	67
ADL-01-0027-1	-H	-H		55, 42, 60	7.7, 15	174
ADL-01-0036-2	-H	-H		0.2, 0.17	0.21, 1.7	27
ADL-01-0064-4	-OH	R=H		0.23	0.16	Not tested
ADL-01-0049-5	-H	-H		5.4, 3.7	0.36, 0.39	39

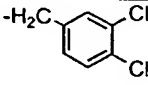
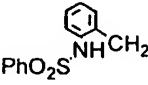
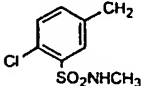
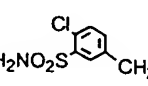
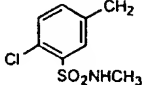
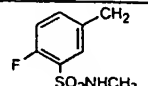
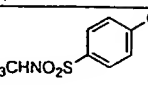
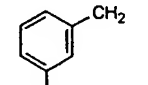
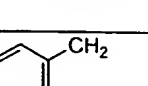
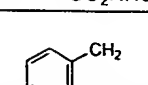
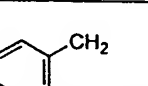
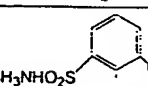
Compounds	X	R	R'	K <sub>i</sub> (nM) k [ <sup>3</sup> H]Diprenorphin	K <sub>i</sub> (nM) k [ <sup>3</sup> H]U69,593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0061-0	-H	-H		0.43, 0.88	0.33, 0.38	29
ADL-01-0054-5	-H	-H		0.94, 0.28	0.5, 0.07, 0.06	13
ADL-01-0058-6	-H	-H		0.12, 0.013	0.050, 0.060	0.009 mg/Kg(s.c.)
ADL-01-0111-3	-H	-H		0.30	0.12	97% @ 300
ADL-01-0123-8	-H	-H		1.3	0.18	98% @ 300
ADL-01-0085-9	-H	-H		22, 13	3.3, 1.3	90% A @ 300
ADL-01-0100-6	-H	-H		65% @ 1mM	98% @ 1mM	43% @ 300
ADL-01-0122-0	-H	-H		52	4.8	51% @ 300
ADL-01-0078-4	-H	-H		5.4, 4.9	2.2, 1.2	Not tested
ADL-01-0110-5	-H	-H		75% at 1 mM	9.0	32% @ 300
ADL-01-0125-3	-H	-H		19	2.2	40% @ 300

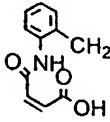
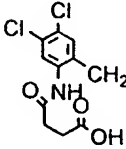
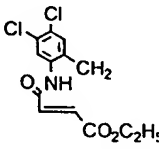
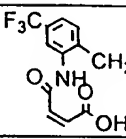
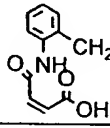
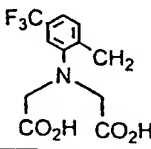
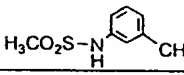
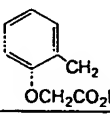
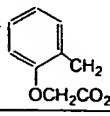
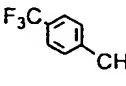
Compounds	X	R	R'	K <sub>i</sub> (nM) k [ <sup>3</sup> H]Diprenorphin	K <sub>i</sub> (nM) k [ <sup>3</sup> H]U69,593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0146-9	-H	-H		100% @ 1mM	91% @ 1mM	94% @ 300
ADL-01-0140-2	-OH	R=H		1.06	0.36	Not tested

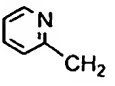
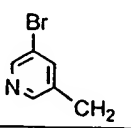
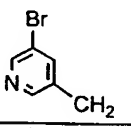
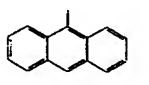
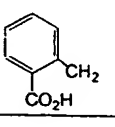
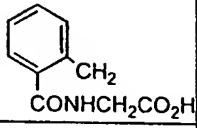
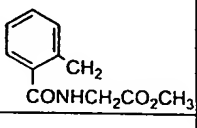
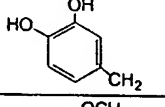
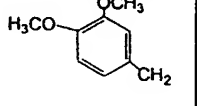
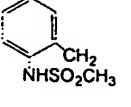
**TABLE IIIA**  
**Compounds of Formula IIIA**



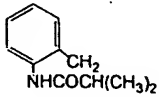
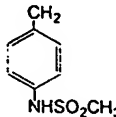
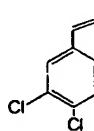
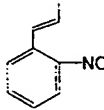
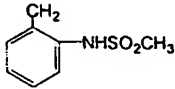
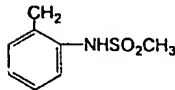
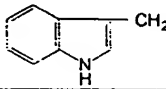
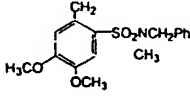
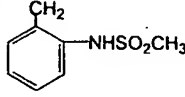
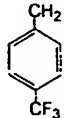
Compound	X	R	R'	K <sub>i</sub> (nM) <sup>3</sup> [H]- Diprenorphin κ	Late Phase Formalin A <sub>50</sub> (mg/kg)
3a	-H	-H		1.0	1.8
3b	-H	-H		464.0	Not tested
3c	-H	-NHSO <sub>2</sub> NH <sub>2</sub>		0.12	0.27
3d	-H	-NHSO <sub>2</sub> Me		0.28	16.0
3e	-H	-NHSO <sub>2</sub> Me		3.2	71% @ 300
3f	-H	-NHSO <sub>2</sub> Me		0.18	8.9
3g	-H	-NHPO <sub>3</sub> Et <sub>2</sub>		0.12	4.4
3h	-H	-NH-maleic acid		1.80	59% @ 10
3i	-H	-NH-C <sub>10</sub> H <sub>16</sub> O <sub>4</sub> N <sub>2</sub>		0.14	23% @ 300

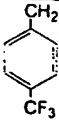


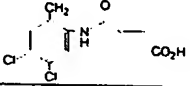
3j	-H	-NH-C <sub>6</sub> H <sub>8</sub> O <sub>3</sub> N		2.3	38% @ 300
3k	-H	-H		18.0	Not tested
3l	-H	-H		3.8	73% @ 300
3m	-H	-H		5.1	65% @ 300
3n	-H	-NHSO <sub>2</sub> CH <sub>3</sub>		7.3	73% @ 300
3o	-H	-H		30.5	59% @ 300
3p	-H	-H		9.7	84% @ 300
3q	-H	-H		3.2	Not tested
3r	-H	-H		7.3	10.0
3s	-H	-H			86% @ 300
3t	-OH	-H		4.2	65% @ 300
3u	-H	-H		1.0	48% @ 300

3v	-OH	-H		46.0	36% @300
3w	-H	-H		2.5	90% @ 300
3y	-H	-H		0.35	Not tested
3z	-H	-H		1.7	98% @ 300
3aa	-H	-H		5279.0	Not tested
3bb	-H	-H		438.0	Not tested
3cc	-H	-H		3.1	52% @ 30
3dd	-H	-H		3.8	65% @ 300
3ee	-H	-H		26.0	34% @ 300
3ff	-OH	-H		0.17	97% @ 300

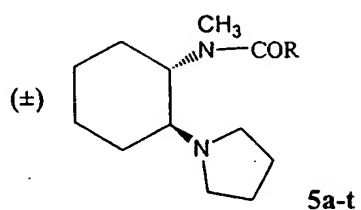
3gg	-OH	-H		5.2	1.4
3hh	-H	-H		0.56	0.11
3ii	-OH	-H		0.44	88% @ 300
3jj	-H	-H		50% @ 1 μM	Not tested
3kk	-H	-H		53% @ 1 μM	23% @ 300
3ll	-H	-H		68% @ 1 μM	77% @ 300
3mm	-H	-H		16.4	53% @ 300
3nn	-H	-H		8.8	Not tested
3oo	-H	-H		2.8	Not tested
3pp	-H	-NHSO2CH3		4.6	Not tested



3qq	-H	-NHCOCH(CH <sub>3</sub> ) <sub>2</sub>		21.0	Not tested
3rr	-H	-H		0.44	2.9
3ss	-H	-H		361.5	Not tested
3tt	-H	-H		164.0	Not tested
3uu	-H	-OCH <sub>3</sub>		17.5	Not tested
3vv	-H	-OH		19.5	Not tested
3ww	-OH	-H		1.28	Not tested
3xx	-H	-H		0.83	Not tested
3yy	-H	-H (R-isomer)		0% @ 1 μM	Not tested
3zz	-H	-OCH <sub>3</sub>		0.64	Not tested

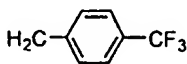
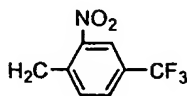
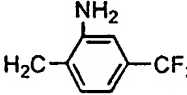
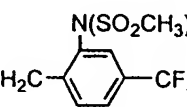
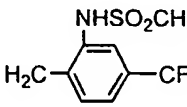
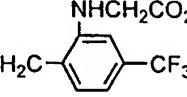
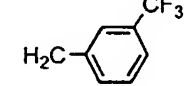
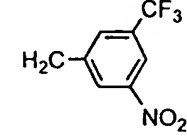
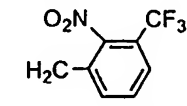
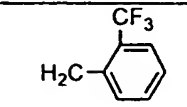
3aaa	-H	-OH		0.59	Not tested
3bbb	-H	-H		4.45	Not tested
3ccc	-H	-H		1.1	Not tested
3ddd	-H	-H			Not tested

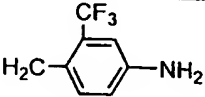
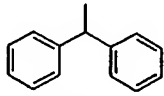
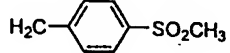
**TABLE IV**  
**Compounds of Formula IV**



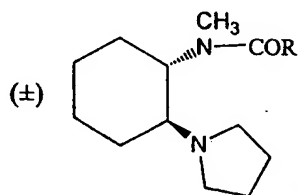
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Compounds	R	K <sub>i</sub> (nM) diprenorphine	K <sub>i</sub> (nM) U-69593	Late Phase Formalin A <sub>50</sub> (mg)
U-50488		4.3	0.6	Not tested
ADL-01-0012-3 (5a)		596	100	Not tested
ADL-01-0014-9 (5b)		1031	433	Not tested
ADL-01-0015-6 (5c)		6.7	1.4	3.5
ADL-01-0016-4 (5d)		10.6	1.7	72.0
ADL-01-0025-5 (5e)		3185	675	Not tested
ADL-01-0028-9 (5f)		14% @ 1μM	866	Not tested

Compounds	R	K <sub>i</sub> (nM) diprenorphine	K <sub>i</sub> (nM) U-69593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0066-9 (5g)		77% @ 1μM	3.75	59% @ 300 μg
ADL-01-0065-1 (5h)		59% @ 1μM	13.4	58% @ 300 μg
ADL-01-0080-0 (5i)		43% @ 1μM	5.4	73% @ 300 μg
ADL-01-0118-8 (5j)		13% @ 1μM	48% @ 1μM	Not tested
ADL-01-0137-8 (5k)		16% @ 1μM	216.0	Not tested
ADL-01-0130-3 (5l)		43.5	2.35	4.7
ADL-01-0083-4 (5m)		192.5	11.25	6.2
ADL-01-0087-5 (5n)		61% @ 1μM	10.85	70% @ 300 μg
ADL-01-0088-3 (5o)		5.65	1.4	86% @ 300 μg
ADL-01-0114-7 (5p)		53% @ 1μM	25.0	Not tested

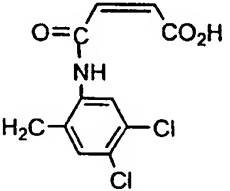
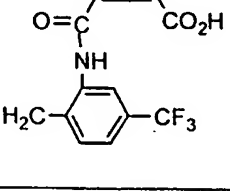
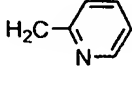
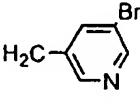
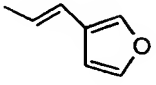
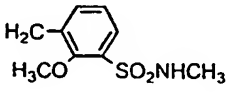
Compounds	R	K <sub>i</sub> (nM) diprenorphine	K <sub>i</sub> (nM) U-69593	Late Phase Formalin A <sub>50</sub> (mg)
ADL-01-0142-8 (5r)		50% @ 1μM	21.0	Not tested
ADL-01-0013-1 (5s)		1171	330	Not tested
ADL-01-0071-9 (5t)		40% @ 1mM	96	Not tested

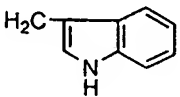
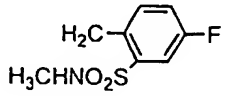
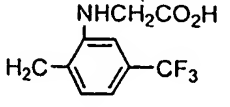
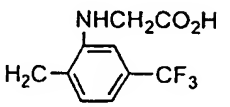
**TABLE IVA**  
**Compounds of Formula IVA**



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Compounds	R	K <sub>i</sub> (nM) [ <sup>3</sup> H]- Diprenorphin	Formalin (% A @ 300μg i-paw or A <sub>50</sub> (mg/kg s.c.)
4a		77.0	26%@300
4b		22% @ 1μM	Not tested
4c		7% @ 1μM	NT
4d		340.5	Not tested
4f		0% @ 1μM	Not tested
4g		294.0	Not tested

4h		164.0	56% @ 300
4i		31% @ 1 $\mu$ M	Not tested
4j (1S,2S)		10.30	91% @ 300
4k (1R,2R)		28% @ 1 $\mu$ M	80% @ 300

### FORMULATIONS OF THE PRESENT INVENTION

5 Effective concentrations of one or more of the compounds of the present invention or pharmaceutically acceptable derivatives thereof are mixed with a suitable pharmaceutical carrier or vehicle for systemic, topical or local administration. Compounds are included in an amount effective for reducing the hyperalgesic state or other symptoms for which treatment is contemplated. The concentration of active compound in the composition will depend on  
 10 absorption, inactivation, excretion rates of the active compound, the dosage schedule, and amount administered as well as other factors known to those of skill in the art. For topical and local administration, the dosages are higher, typically at least about 5 to 10 fold, than the amount delivered when administered systemically orally.

The compounds of the present invention possess analgesic activity and can be used for  
 15 the relief of pain without loss of consciousness. For example, compounds can be used to treat muscle spasm, arthritis and other musculoskeletal conditions, *e.g.*, bursitis, relieve mild to moderate postoperative and postpartum pain, dysmenorrhea and pain of traumatic origin. Additionally, the compounds of the present invention can be administered for the treatment of severe pain, *e.g.*, pain associated with adenocarcinoma, amputation of a limb, and third  
 20 degree burns over a major portion of the body in animals and humans.

Selected compounds of the present invention have activity as narcotic antagonists. They can be used to counteract or prevent excessive central nervous system depression and

respiratory depression resulting from the administration of morphine or other morphine-like drugs, *e.g.*, hydromorphone, oxymorphone, methadone and meperidine. The compounds are also capable of inducing an abstinence syndrome in narcotic addicted subjects, *i.e.*, induce withdrawal effects for diagnostic purposes.

5       The dosage of the compound of Formulas I, IA, II, IIA, III, IIIA, IV, and IVA for analgesic purposes is from about 0.001 to about 20 mg/kg body weight of the patient. The compounds of Formulas I, IA, II, IIA, III, IIIA, IV, and IVA are conveniently prepared in 5, 10, 25, 50, 75, 100 and 200 mg dosage units for administration for 1 to 4 times a day. Preferred unit dosages are from 0.05 to 10 mg/kg body weight of the patient.

10       The compounds are administered orally, parenterally, rectally and topically.

Pharmaceutical carriers or vehicles suitable for administration of the compounds and for the methods provided herein include any such carriers known to those skilled in the art to be suitable for the particular mode of administration. In addition, the compounds may be formulated as the sole pharmaceutically active ingredient in the composition or may be  
15       combined with other active ingredients.

#### a) Systemic Formulations

The formulations of the present invention are provided for administration to humans and animals in unit dosage forms, such as tablets, capsules, pills, powders, granules, sterile  
20       parenteral solutions or suspensions, and oral solutions or suspensions, and oil-water emulsions containing suitable quantities of a compound of Formulas I, IA, II, IIA, III, IIIA, IV, and IVA or pharmacologically acceptable salts thereof.

Pharmaceutical dosage unit forms are prepared to provide from about 0.05 mg to about 500 mg and preferably from about 1.0 to about 200 mg of the essential active  
25       ingredient or a combination of essential ingredients per dosage unit form.

Oral pharmaceutical dosage forms are either solid or liquid. The solid dosage forms are tablets, capsules, granules, and bulk powders. Types of oral tablets include compressed, chewable lozenges and tablets which may be enteric-coated, sugar-coated or film-coated. Capsules may be hard or soft gelatin capsules, while granules and powders may be provided  
30       in non-effervescent or effervescent form with the combination of other ingredients known to those skilled in the art.

Pharmaceutically acceptable carriers utilized in tablets are binders, lubricants, diluents, disintegrating agents, coloring agents, flavoring agents, and wetting agents. Enteric-coated tablets, due to their enteric-coating, resist the action of stomach acid and dissolve or  
35       disintegrate in the neutral or alkaline intestines. Sugar-coated tablets are compressed tablets to which different layers of pharmaceutically acceptable substances have been applied. Film-coated tablets are compressed tablets which have been coated with a water soluble polymers. Multiple compressed tablets are compressed tablets made by more than one compression



cycle utilizing the pharmaceutically acceptable substances previously mentioned. Coloring agents may also be used in the above dosage forms. Flavoring and sweetening agents are used in compressed tablets, sugar-coated, multiple compressed and chewable tablets. Flavoring and sweetening agents are especially useful in the formation of chewable tablets and lozenges.

Examples of binders include glucose solution, acacia mucilage, gelatin solution, sucrose and starch paste. Lubricants include talc, starch, magnesium or calcium stearate, lycopodium and stearic acid. Diluents include, for example, lactose, sucrose, starch, kaolin, salt, mannitol and dicalcium phosphate. Disintegrating agents include corn starch, potato starch, bentonite, methylcellulose, agar and carboxymethylcellulose. Coloring agents include, for example, any of the approved certified water soluble FD and C dyes, mixtures thereof, and water insoluble FD and C dyes suspended on alumina hydrate. Sweetening agents include sucrose, lactose, mannitol and artificial sweetening agents such as sodium cyclamate and saccharin, and any number of spray dried flavors. Flavoring agents include natural flavors extracted from plants such as fruits and synthetic blends of compounds which produce a pleasant sensation. Wetting agents include propylene glycol monostearate, sorbitan monoleate, diethylene glycol monolaurate and polyoxyethylene lauryl ether. Enteric-coatings include fatty acids, fats, waxes, shellac, ammoniated shellac and cellulose acetate phthalates. Film coatings include hydroxyethylcellulose, sodium carboxymethylcellulose, polyethylene glycol 4000 and cellulose acetate phthalate.

Liquid oral dosage forms include aqueous solutions, emulsions, suspensions, solutions and/or suspensions reconstituted from non-effervescent granules and effervescent preparations reconstituted from effervescent granules. Aqueous solutions include, for example, elixirs and syrups. Emulsions are either oil-in water or water-in-oil.

Elixirs are clear, sweetened, hydroalcoholic preparations. Pharmaceutically acceptable carriers used in elixirs include solvents. Syrups are concentrated aqueous solutions of a sugar, for example, sucrose, and may contain a preservative. An emulsion is a two-phase system in which one liquid is dispersed in the form of small globules throughout another liquid. Pharmaceutically acceptable carriers used in emulsions are non-aqueous liquids, emulsifying agents and preservatives. Suspensions use pharmaceutically acceptable suspending agents and preservatives. Pharmaceutically acceptable substances used in non-effervescent granules, to be reconstituted into a liquid oral dosage form, include diluents, sweeteners and wetting agents. Pharmaceutically acceptable substance used in effervescent granules, to be reconstituted into a liquid oral dosage form, include organic acids and a source of carbon dioxide. Coloring and flavoring agents are used in all of the above dosage forms.

Solvents include glycerin, sorbitol, ethyl alcohol and syrup. Examples of preservatives include glycerin, methyl and propylparaben, benzoic acid, sodium benzoate and alcohol. Examples of non-aqueous liquids utilized in emulsions include mineral oil and

cottonseed oil. Examples of emulsifying agents include gelatin, acacia, tragacanth, bentonite, and surfactants such as polyoxyethylene sorbitan monooleate. Suspending agents include sodium carboxymethylcellulose, pectin, tragacanth, Veegum and acacia. Diluents include lactose and sucrose. Sweetening agents include sucrose, syrups, glycerin and artificial  
5 sweetening agents such as sodium cyclamate and saccharin. Wetting agents include propylene glycol monostearate, sorbitan monooleate, diethylene glycol monolaurate and polyoxyethylene lauryl ether. Organic acids include citric and tartaric acid. Sources of carbon dioxide include sodium bicarbonate and sodium carbonate. Coloring agents include any of the approved certified water soluble FD and C dyes, and mixtures thereof. Flavoring  
10 agents include natural flavors extracted from plants such fruits, and synthetic blends of compounds which produce a pleasant taste sensation.

Parenteral administration of the formulations of the present invention includes intravenous, subcutaneous and intramuscular administrations.

Preparations for parenteral administration include sterile solutions ready for injection,  
15 sterile dry soluble products ready to be combined with a solvent just prior to use, including hypodermic tablets, sterile suspensions ready for injection, sterile dry insoluble products ready to be combined with a vehicle just prior to use and sterile emulsions. The solutions may be either aqueous or nonaqueous.

Pharmaceutically acceptable carriers used in parenteral preparations include aqueous  
20 vehicles, nonaqueous vehicles, antimicrobial agents, isotonic agents, buffers, antioxidants, local anesthetics, suspending and dispersing agents, emulsifying agents, sequestering or chelating agents and other pharmaceutically acceptable substances.

Examples of aqueous vehicles include Sodium Chloride Injection, Ringers Injection, Isotonic Dextrose Injection, Sterile Water Injection, Dextrose and Lactated Ringers Injection.  
25 Nonaqueous parenteral vehicles include fixed oils of vegetable origin, cottonseed oil, corn oil, sesame oil and peanut oil. Antimicrobial agents in bacteriostatic or fungistatic concentrations must be added to parenteral preparations packaged in multiple-dose containers which include phenols or cresols, mercurials, benzyl alcohol, chlorobutanol, methyl and propyl p-hydroxybenzoic acid esters, thimerosal, benzalkonium chloride and benzethonium  
30 chloride. Isotonic agents include sodium chloride and dextrose. Buffers include phosphate and citrate. Antioxidants include sodium bisulfate. Local anesthetics include procaine hydrochloride. Suspending and dispersing agents include sodium carboxymethylcellulose, hydroxypropyl methylcellulose and polyvinylpyrrolidone. Emulsifying agents include Polysorbate 80 (Tween 80). A sequestering or chelating agent of metal ions include EDTA.  
35 Pharmaceutical carriers also include ethyl alcohol, polyethylene glycol and propylene glycol for water miscible vehicles and sodium hydroxide, hydrochloric acid, citric acid or lactic acid for pH adjustment.

The concentration of the pharmaceutically active compound is adjusted so that an injection provides an effective amount to produce the desired pharmacological effect. The exact dose depends on the age, weight and condition of the patient or animal as is known in the art.

5       The unit-dose parenteral preparations are packaged in an ampoule or a syringe with a needle.

All preparations for parenteral administration must be sterile, as is known and practiced in the art.

10       Illustratively, intravenous or intraarterial infusion of a sterile aqueous solution containing an active compound is an effective mode of administration. Another embodiment is a sterile aqueous or oily solution or suspension containing an active material injected as necessary to produce the desired pharmacological effect.

Pharmaceutical dosage forms for rectal administration are rectal suppositories, capsules and tablets for systemic effect.

15       Rectal suppositories are used herein mean solid bodies for insertion into the rectum which melt or soften at body temperature releasing one or more pharmacologically or therapeutically active ingredients.

Pharmaceutically acceptable substances utilized in rectal suppositories are bases or vehicles and agents to raise the melting point.

20       Examples of bases include cocoa butter (theobroma oil), glycerin-gelatin, carbowax, (polyoxyethylene glycol) and appropriate mixtures of mono-, di- and triglycerides of fatty acids. Combinations of the various bases may be used. Agents to raise the melting point of suppositories include spermaceti and wax. Rectal suppositories may be prepared either by the compressed method or by molding. The typical weight of a rectal suppository is about 2 to 3

25       gm.

Tablets and capsules for rectal administration are manufactured using the same pharmaceutically acceptable substance and by the same methods as for formulations for oral administration.

30       The pharmaceutically therapeutically active compounds of Formulas I, II, III and IV are administered orally, parenterally or rectally in unit-dosage forms or multiple-dosage forms. Unit-dose forms as used herein refers to physically discrete units suitable for human and animal subjects and packaged individually as is known in the art. Each unit-dose contains a predetermined quantity of the therapeutically active compound sufficient to produce the desired therapeutic effect, in association with the required pharmaceutical carrier, vehicle or diluent. Examples of unit-dose forms include ampoules and syringes individually

35       packaged tablet or capsule. Unit-dose forms may be administered in fractions or multiples thereof. A multiple-dose form is a plurality of identical unit-dosage forms packaged in a single container to be administered in segregated unit-dose form. Examples of multiple-dose

forms include vials, bottles of tablets or capsules or bottles of pint or gallons. Hence, multiple dose form is a multiple of unit-doses which are not segregated in packaging.

Compounds of the present invention in formulations may be included with other active compounds to obtain desired combinations of properties. Other active compounds with known pharmacological properties include analgesics such as aspirin, phenacetin acetaminophen, propoxyphene, pentazocine, codeine, meperidine, oxycodone, mefenamic acid, and ibuprofen; muscle relaxants such as methocarbamol, orphenadrine, carisoprodol, meprobamate, chlorphenesin carbamate, diazepam, chlordiazepoxide and chlorzoxazone; analeptics such as caffeine, methylphenidate and pentylenetetrazol; corticosteroids such as methylprednisolone, prednisone, prednisolone and dexamethasone; antihistamines such as chlorpheniramine, cyproheptadine, promethazine and pyrilamine.

#### **b) Local and Topical Formulations**

Typically a therapeutically effective dosage is formulated to contain a concentration of at least about 0.1% w/w up to about 50% w/w or more, preferably more than 1% w/w of the active compound to the treated tissue. The active ingredient may be administered at once, or may be divided into a number of smaller doses to be administered at intervals of time. It is understood that the precise dosage and duration of treatment is a function of the tissue being treated and may be determined empirically using known testing protocols or by extrapolation from in vivo or in vitro test data. It is to be noted that concentrations and dosage values may also vary with the age of the individual treated. It is to be further understood that for any particular subject, specific dosage regimens should be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the formulations, and that the concentration ranges set forth herein are exemplary only and are not intended to limit the scope or practice of the claimed formulations.

The compound may be suspended in micronized or other suitable form or may be derivatized to produce a more soluble active product or to produce a prodrug. The form of the resulting mixture depends upon a number of factors, including the intended mode of administration and the solubility of the compound in the selected carrier or vehicle. The effective concentration is sufficient for ameliorating the hyperalgesic or other condition and may be empirically determined.

Compounds are typically included at concentrations 0.001% w/w or greater than 1% w/w up to 50% w/w or higher. The concentration is generally greater than the concentration for systemic administration of the compound. Preferable concentrations are in the range of 0.01% w/w to about 25%w/w, more preferably 1% w/w to 25% w/w, yet more preferably greater than about 1% w/w to about 10% w/w, and most preferably greater than 1% w/w up to about 5% w/w. Aqueous suspensions and formulations contain 1% w/w or more.

The resulting mixture may be a solution, suspension, emulsions or the like and are formulated as creams, gels, ointments, emulsions, solutions, elixirs, lotions, suspensions, tinctures, pastes, foams, aerosols, irrigations, sprays, suppositories, bandages, or any other formulations suitable for topical or local administration.

5 The route of administration herein is topical or local administration, and compositions are formulated in a manner suitable for each route of administration. Preferred modes of administration include topical application to the skin, eyes or mucosa, and local application to the joints, such as by intra-articular injection. Thus, typical vehicles are those suitable for pharmaceutical or cosmetic application to body surfaces or for local injection.

10 Pharmaceutical and cosmetic carriers or vehicles suitable for administration of the compounds provided herein include any such carriers known to those skilled in the art to be suitable for the particular mode of administration. In addition, the compounds may be formulated as the sole pharmaceutically active ingredient in the composition or may be combined with other active ingredients. The active compound is included in the carrier in an  
15 amount sufficient to exert a therapeutically useful effect in the absence of serious toxic effects on the treated individual. The effective concentration may be determined empirically by testing the compounds using in vitro and in vivo systems, including the animal models described herein.

For topical administration, the compounds may be formulated in compositions in the  
20 form of gels, creams, lotions, solids, solutions or suspensions, or aerosols. Compositions for treating human skin are formulated for topical application with an anti-hyperalgesic effective amount of one or more of the compounds selected as described herein, in an effective concentration range [by weight], between about 0.1% and 80%, preferably 0.1 to 50%, more preferably greater than about 1% up to about 50% or more in a cream, ointment, lotion, gel,  
25 solution or solid base or vehicle known in the art to be non-toxic and dermatologically acceptable or suitable for application to the mucosa. Aqueous suspensions are preferably formulated at concentrations greater than about 1% w/w, more preferably 2% w/w.

To formulate a composition, the weight fraction of compound is dissolved, suspended, dispersed or otherwise mixed in a selected vehicle at an effective concentration such that the  
30 hyperalgesic condition is relieved or ameliorated. Generally, emollient or lubricating vehicles that help hydrate the skin are more preferred than volatile vehicles, such as ethanol, that dry the skin. Examples of suitable bases or vehicles for preparing compositions for use with human skin are petrolatum, petrolatum plus volatile silicones, lanolin, cold cream [USP], and hydrophilic ointment [USP].

35 The choice of an acceptable vehicle is largely determined by the mode of application and tissue to be treated. Suitable pharmaceutically and dermatologically acceptable vehicles for topical application include those suited for use include lotions, creams, solutions, gels, tapes and the like. Generally, the vehicle is either organic in nature or an aqueous emulsion

and capable of having the selected compound or compounds, which may be micronized, dispersed, suspended or dissolved therein. The vehicle may include pharmaceutically-acceptable emollients, skin penetration enhancers, coloring agents, fragrances, emulsifiers, thickening agents, and solvents.

- 5 For local internal administration, such as intra-articular administration, the compounds are preferably formulated as a suspension in an aqueous-based medium, such as isotonic buffered saline or are combined with a biocompatible support or bioadhesive intended for internal administration.

## 10 Lotions

The lotions contain an effective concentration of one or more of the compounds. The effective concentration is preferably effective to deliver an anti-hyperalgesic amount, typically at a concentration of between about 0.1 - 50% w/w or more of one or more of the compounds provided herein. The lotions also contain from 1% to 50% w/w, preferably from 15 3% to 15% w/w of an emollient and the balance water, a suitable buffer, a C<sub>2</sub> or C<sub>3</sub> alcohol, or a mixture of water of the buffer and the alcohol. Any emollients known to those of skill in the art as suitable for application to human skin may be used. These include, but are not limited to, the following:

(a) Hydrocarbon oils and waxes, including mineral oil, petrolatum, paraffin, 20 ceresin, ozokerite, microcrystalline wax, polyethylene, and perhydrosqualene.

(b) Silicone oils, including dimethylpolysiloxanes, methylphenylpolysiloxanes, water-soluble and alcohol-soluble silicone-glycol copolymers.

(c) Triglyceride fats and oils, including those derived from vegetable, animal and marine sources. Examples include, but are not limited to, castor oil, safflower oil, cotton seed 25 oil, corn oil, olive oil, cod liver oil, almond oil, avocado oil, palm oil, sesame oil and soybean oil.

(d) Acetoglyceride esters, such as acetylated monoglycerides.

(e) Ethoxylated glycerides, such as ethoxylated glyceryl monostearate.

(f) Alkyl esters of fatty acids having 10 to 20 carbon atoms. Methyl, isopropyl and 30 butyl esters of fatty acids are useful herein. Examples include, but are not limited to, hexyl laurate, isohexyl laurate, isohexyl palmitate, isopropyl palmitate, isopropyl myristate, decyl oleate, isodecyl oleate, hexadecyl stearate, decyl stearate, isopropyl isostearate diisopropyl adipate, diisohexyl adipate, dihexyldecyl adipate, diisopropyl sebacate, lauryl lactate, myristyl lactate, and cetyl lactate.

(g) Alkenyl esters of fatty acids having 10 to 20 carbon atoms. Examples thereof 35 include, but are not limited to, oleyl myristate, oleyl stearate, and oleyl oleate.

(h) Fatty acids having 9 to 22 carbon atoms. Suitable examples include, but are not limited to pelargonic, lauric, myristic, palmitic, stearic, isostearic, hydroxystearic, oleic, linoleic, ricinoleic, arachidonic, behenic, and erucic acids.

5 (i) Fatty alcohols having 10 to 20 carbon atoms, such as but not limited to, lauryl, myristyl, cetyl, hexadecyl, stearyl, isostearyl, hydroxystearyl, oleyl, ricinoleyl, behenyl, erucyl, and 2-octyl dodecyl alcohols.

(j) Fatty alcohol ethers, including, but not limited to, ethoxylated fatty alcohols of 10 to 20 carbon atoms, such as, but are not limited to, the lauryl cetyl, stearyl, isostearyl, oleyl, and cholesterol alcohols having attached thereto from 1 to 50 ethylene oxide groups or  
10 1 to 50 propylene oxide groups or mixtures thereof.

(k) Ether-esters, such as fatty acid esters of ethoxylated fatty alcohols.

(l) Lanolin and derivatives, including but not limited to, lanolin, lanolin oil, lanolin wax, lanolin alcohols, lanolin fatty acids, isopropyl lanolate, ethoxylated lanolin, ethoxylated lanolin alcohols, ethoxylated cholesterol, propoxylated lanolin alcohols, acetylated lanolin,  
15 acetylated lanolin alcohols, lanolin alcohols linoleate, lanolin alcohols ricinoleate, acetate of lanolin alcohols ricinoleate, acetate of ethoxylated alcohols-esters, hydrogenolysis of lanolin, ethoxylated hydrogenated lanolin, ethoxylated sorbitol lanolin, and liquid and semisolid lanolin absorption bases.

(m) Polyhydric alcohols and polyether derivatives, including, but not limited to,  
20 propylene glycol, dipropylene glycol, polypropylene glycol [M.W. 2000-4000], polyoxyethylene polyoxypropylene glycols, polyoxypropylene polyoxyethylene glycols, glycerol, ethoxylated glycerol, propoxylated glycerol, sorbitol, ethoxylated sorbitol, hydroxypropyl sorbitol, polyethylene glycol [M.W. 200-6000], methoxy polyethylene glycols 350, 550, 750, 2000, 5000, poly(ethylene oxide) homopolymers [M.W. 100,000 - 5,000,000],  
25 polyalkylene glycols and derivatives, hexylene glycol (2-methyl-2,4-pentanediol), 1,3-butylene glycol, 1,2,6-hexanetriol, ethohexadiol USP (2-ethyl-1,3-hexanediol), C<sub>15</sub>-C<sub>18</sub> vicinal glycol and polyoxypropylene derivatives of trimethylolpropane.

(n) Polyhydric alcohol esters, including, but not limited to, ethylene glycol mono- and di-fatty acid esters, diethylene glycol mono- and di-fatty acid esters, polyethylene glycol  
30 [M.W. 200-6000], mono- and di-fatty esters, propylene glycol mono- and di-fatty acid esters, polypropylene glycol 2000 monooleate, polypropylene glycol 2000 monostearate, ethoxylated propylene glycol monostearate, glyceryl mono- and di-fatty acid esters, polyglycerol poly-fatty acid esters, ethoxylated glyceryl monostearate, 1,3-butylene glycol monostearate, 1,3-butylene glycol distearate, polyoxyethylene polyol fatty acid ester, sorbitan  
35 fatty acid esters, and polyoxyethylene sorbitan fatty acid esters.

(o) Wax esters, including, but not limited to, beeswax, spermaceti, myristyl myristate, and stearyl stearate and beeswax derivatives, including, but not limited to,

polyoxyethylene sorbitol beeswax, which are reaction products of beeswax with ethoxylated sorbitol of varying ethylene oxide content that form a mixture of ether-esters.

- (p) Vegetable waxes, including, but not limited to, carnauba and candelilla waxes.
- (q) Phospholipids, such as lecithin and derivatives.
- 5 (r) Sterols, including, but not limited to, cholesterol and cholesterol fatty acid esters.
- (s) Amides, such as fatty acid amides, ethoxylated fatty acid amides, and solid fatty acid alkanolamides.

The lotions further preferably contain from 1% w/w to 10% w/w, more preferably  
10 from 2% w/w to 5% w/w, of an emulsifier. The emulsifiers can be nonionic, anionic or cationic. Examples of satisfactory nonionic emulsifiers include, but are not limited to, fatty alcohols having 10 to 20 carbon atoms, fatty alcohols having 10 to 20 carbon atoms condensed with 2 to 20 moles of ethylene oxide or propylene oxide, alkyl phenols with 6 to 12 carbon atoms in the alkyl chain condensed with 2 to 20 moles of ethylene oxide, mono-  
15 and di-fatty acid esters of ethylene oxides mono- and di-fatty acid esters of ethylene glycol wherein the fatty acid moiety contains from 10 to 20 carbon atoms, diethylene glycol, polyethylene glycols of molecular weight 200 to 6000, propylene glycols of molecular weight 200 to 3000, glycerol, sorbitol, sorbitan, polyoxyethylene sorbitol, polyoxyethylene sorbitan and hydrophilic wax esters. Suitable anionic emulsifiers include, but are not limited to, the  
20 fatty acid soaps, e.g. sodium, potassium and triethanolamine soaps, wherein the fatty acid moiety contains from 10 to 20 carbon atoms. Other suitable anionic emulsifiers include, but are not limited to, the alkali metal, ammonium or substituted ammonium alkyl sulfates, alkyl arylsulfonates, and alkyl ethoxy ether sulfonates having 10 to 30 carbon atoms in the alkyl moiety. The alkyl ethoxy ether sulfonates contain from 1 to 50 ethylene oxide units. Among  
25 satisfactory cationic emulsifiers are quaternary ammonium, morpholinium and pyridinium compounds. Certain of the emollients described in preceding paragraphs also have emulsifying properties. When a lotion is formulated containing such an emollient, an additional emulsifier is not needed, though it can be included in the composition.

The balance of the lotion is water or a C<sub>2</sub> or C<sub>3</sub> alcohol, or a mixture of water and the  
30 alcohol. The lotions are formulated by simply admixing all of the components together. Preferably, the compound, is dissolved, suspended or otherwise uniformly dispersed in the mixture.

Other conventional components of such lotions may be included. One such additive is a thickening agent at a level from 1% to 10% w/w of the composition. Examples of  
35 suitable thickening agents include, but are not limited to: cross-linked carboxypolymethylene polymers, ethyl cellulose, polyethylene glycols, gum, tragacanth, gum kharaya, xanthan gums and bentonite, hydroxyethyl cellulose, and hydroxypropyl cellulose.



### Creams

The creams are formulated to contain concentration effective to deliver an anti-hyperalgesic effective amount of the compound to the treated tissue, typically at between about 0.1%, preferably at greater than 1% up to and greater than 50%, preferably between about 3% and 50%, more preferably between about 5% and 15% of one or more of the compounds provided herein. The creams also contain from 5% to 50%, preferably from 10% to 25%, of an emollient and the remainder is water or other suitable non-toxic carrier, such as an isotonic buffer. The emollients, as described above for the lotions, can also be used in the cream compositions. The cream may also contain a suitable emulsifier, as described above. The emulsifier is included in the composition at a level from 3% to 50%, preferably from 5% to 20%.

### Solutions and suspensions for topical and local administration

The solutions are formulated to contain an amount of one or more compounds effective to deliver an anti-hyperalgesic amount, typically at a concentration of between about 0.1 - 50% w/w, preferably at least more than 1% w/w, more preferably more than 2% w/w of one or more of the compounds provided herein. The balance is water, a suitable organic solvent or other suitable solvent or buffer. Suitable organic materials useful as the solvent or a part of a solvent system are as follows: propylene glycol, polyethylene glycol [M.W. 200-600], polypropylene glycol [M.W. 425-2025], glycerine, sorbitol esters, 1,2,6-hexanetriol, ethanol, isopropanol, diethyl tartrate, butanediol and mixtures thereof. Such solvent systems can also contain water.

Solutions or suspensions used for local application can include any of the following components: a sterile diluent, such as water for injection, saline solution, fixed oil, polyethylene glycol, glycerine, propylene glycol or other synthetic solvent; antimicrobial agents, such as benzyl alcohol and methyl parabens; antioxidants, such as ascorbic acid and sodium bisulfite; chelating agents, such as ethylenediaminetetraacetic acid [EDTA]; buffers, such as acetates, citrates and phosphates; and agents for the adjustment of tonicity such as sodium chloride or dextrose. Liquid preparations can be enclosed in ampoules, disposable syringes or multiple dose vials made of glass, plastic or other suitable material. Suitable carriers may include physiological saline or phosphate buffered saline [PBS], and the suspensions and solutions may contain thickening and solubilizing agents, such as glucose, polyethylene glycol, and polypropylene glycol and mixtures thereof. Liposomal suspensions, may also be suitable as pharmaceutically acceptable carriers. These may be prepared according to methods known to those skilled in the art.

These compositions that are formulated as solutions or suspensions may be applied to the skin, or may be formulated as an aerosol or foam and applied to the skin as a spray-on. The aerosol compositions typically contain from 25% to 80% w/w, preferably from 30% to

50% w/w, of a suitable propellant. Examples of such propellants are the chlorinated, fluorinated and chlorofluorinated lower molecular weight hydrocarbons. Nitrous oxide, carbon dioxide, butane, and propane are also used as propellant gases. These propellants are used as understood in the art in a quantity and under a pressure suitable to expel the contents of the container.

Suitably prepared solutions and suspension may also be topically applied to the eyes and mucosa. Solutions, particularly those intended for ophthalmic use, may be formulated as 0.01% - 10% w/w isotonic solutions, pH about 5-7, with appropriate salts, and preferably containing one or more of the compounds herein at a concentration of about 0.1% w/w preferably greater than 1% w/w, up to 50% w/w or more. Suitable ophthalmic solutions are known [see, e.g. U.S. Patent No. 5,116,868, which describes typical compositions of ophthalmic irrigation solutions and solutions for topical application]. Such solutions, which have a pH adjusted to about 7.4, contain, for example, 90-100 mM sodium chloride, 4-6 mM dibasic potassium phosphate, 4-6 mM dibasic sodium phosphate, 8-12 mM sodium citrate, 0.5-1.5 mM magnesium chloride, 1.5-2.5 mM calcium chloride, 15-25 mM sodium acetate, 10-20 mM D.L.-sodium  $\beta$ -hydroxybutyrate and 5-5.5 mM glucose.

The active compounds of the present invention can also be mixed with other active materials, that do not impair the desired action, or with materials that supplement the desired action, including viscoelastic materials, such as hyaluronic acid, which is sold under the trademark HEALON [solution of a high molecular weight (MW of about 3 million) fraction of sodium hyaluronate; manufactured by Pharmacia, Inc. see, e.g., U.S. Patent Nos. 5,292,362, 5,282,851, 5,273,056, 5,229,127, 4,517,295 and 4,328,803], VISCOAT [fluorine-containing (meth) acrylates, such as, 1H, 2H, 2H-heptadecafluorodecylmethacrylate; see, e.g., U.S. Patent Nos. 5,278,126, 5,273,751 and 5,214,080; commercially available from Alcon Surgical, Inc.], ORCOLON [see, e.g., U.S. Patent Nos. 5,273,056; commercially available from Optical Radiation Corporation], methylcellulose, methyl hyaluronate, polyacrylamide and polymethacrylamide [see, e.g., U.S. Patent No. 5,273,751]. The viscoelastic materials are present generally in amounts ranging from about 0.5 to 5.0% w/w, preferably 1 to 3% w/w of the conjugate material and serve to coat and protect the treated tissues. The compositions may also include a dye, such as methylene blue or other inert dye, so that the composition can be seen when injected into the eye or contacted with the surgical site during surgery.

### Gels

Gel compositions can be formulated by simply admixing a suitable thickening agent to the previously described solution or suspension composition. Examples of suitable thickening agents have been previously described with respect to the lotions.

The gelled compositions contain an effective amount of one or more of an antihyperalgesic amount, typically at a concentration of between about 0.1 - 50% w/w or

more of one or more of the compounds provided therein; from 5% to 75% w/w, preferably from 10% to 50% w/w, of an organic solvent as previously described; from 0.5% to 20% w/w, preferably from 1% to 10% w/w of the thickening agent; the balance being water or other aqueous carrier.

5

### Solids

Compositions of solid forms may be formulated as stick-type compositions intended for application to the lips or other parts of the body. Such compositions contain an effective amount of one or more of the compounds provided therein. The amount is typically an amount effective to deliver an anti-hyperperalgesic amount, typically at a concentration of between about 0.1 - 50% w/w or more of one or more of the compounds provided herein. The solids also contain from about 40% to 98% w/w, preferably from about 50% to 90% w/w, of the previously described emollients. This composition can further contain from 1% to 20% w/w, preferably from 5% to 15% w/w, of a suitable thickening agent, and, if desired or needed, emulsifiers and water or buffers. Thickening agents previously described with respect to lotions are suitably employed in the composition in solid form.

Other ingredients such as preservatives, including methyl-paraben or ethyl-paraben, perfumes, dyes or the like, that are known in the art to provide desirable stability, fragrance or color, or other desirable properties, such as shielding from actinic rays from the sun, to compositions for application to the skin may also be employed in a composition for such topical application.

### Additional ingredients

Other active ingredients include, but are not limited to, antibiotics, antivirals, antifungals, anti-inflammatories, including steroidal and non-steroidal anti-inflammatories, anesthetics and mixtures thereof. Such additional ingredients include any of the following:

#### a. Antibacterial agents

Aminoglycosides, such as Amikacin, Apramycin, Arbekacin, Bambarmycins, Butirosin, Dibekacin, Dihydrostreptomycin, Fortimicin(s), Fradiomycin, Gentamicin, Ispamicin, Kanamycin, Micronomicin, Neomycin, Neomycin Undecylenate, Netilmicin, Paromomycin, Ribostamycin, Sisomicin, Spectinomycin, Streptomycin, Streptonicozid and Tobramycin;

Amphenicols, such as Azidamfenicol, Chloramphenicol, Chloramphenicol Palmirate, Chloramphenicol Pantothenate, Florfenicol, Thiamphenicol;

35 Ansamycins, such as Rifamide, Rifampin, Rifamycin and Rifaximin;

B-Lactams;

Carbapenems, such as Imipenem;

Cephalosporins, such as 1-Carba (dethia) Cephalosporin, Cefactor, Cefadroxil, Cefamandole, Cefatrizine, Cefazedone, Cefazolin, Cefixime, Cefmenoxime, Cefodizime, Cefonicid, Cefoperazone, Ceforanide, Cefotaxime, Cefotiam, Cefpimizole, Cefpirimide, Cefpodoxime Proxetil, Cefroxadine, Cefsulodin, Ceftazidime, Cefteram, Ceftezole, 5 Ceftibuten, Ceftizoxime, Ceftriaxone, Cefuroxime, Cefuzonam, Cephacetrile Sodium, Cephalixin, Cephaloglycin, Cephaloridine, Cephalosporin, Cephalothin, Cephapirin Sodium, Cephradine and Pivcefalexin;

Cephameycins such as Cefbuperazone, Cefmetazole, Cefminox, Cefetan and Cefoxitin;

10 Monobactams such as Aztreonam, Carumonam and Tigemonan;

Oxacephems such as Flomoxef and Moxolactam;

Penicillins such as Amidinocillin, Amdinocillin, Pivoxil, Amoxicillin, Ampicillan, Apalcillin, Aspoxicillin, Azidocillin, Azlocillin, Bacampicillin, Benzylpenicillinic Acid, Benzylpenicillin, Carbenicillin, Carfecillin, Carindacillin, 15 Clometocillin, Cloxacillin, Cyclacillin, Dicloxacillin, Diphenicillin, Epicillin, Fenbenicillin, Floxicillin, Hetacillin, Lenampicillin, Metampicillin, Methicillin, Mezlocillin, Nafcillin, Oxacillin, Penamecillin, Penethamate Hydriodide, Penicillin G Benethamine, Penicillin G Benzathine, Penicillin G Benzhydrylamine, Penicillin G Calcium, Penicillin G Hydragamine, Penicillin G Potassium, Penicillin G. Procaine, Penicillin N, Penicillin O, Penicillin V, 20 Penicillin V Benzathine, Penicillin V Hydrabamine, Penimepicycline, Phenethicillin, Piperacillin, Pivapicillin, Propicillin, Quinacillin, Sulbenicillin, Talampicillin, Temocillin and Ticarcillin;

Lincosamides such as Clindamycin and Lincomycin;

Macrolides such as Azithromycin, Carbomycin, Clarithromycin, 25 Erythromycin(s) and Derivatives, Josamycin, Leucomycins, Midecamycins, Miokamycin, Oleandomycin, Primycin, Rokitamycin, Rosaramicin, Roxithromycin, Spiramycin and Troleandomycin;

Polypeptides such as Amphomycin, Bacitracin, Capreomycin, Colistin, Enduracidin, Enviomycin, Fusafungine, Gramicidin(s), Gramicidin S, Mikamycin, 30 Polymyxin, Polymyxin  $\beta$ -Methanesulfonic Acid, Pristinamycin, Ristocetin, Teicoplanin, Thiostrepton, Tuberactinomycin, Tyrocidine, Tyrothricin, Vancomycin, Viomycin(s), Virginiamycin and Zinc Bacitracin;

Tetracyclines such as Spicycline, Chlortetracycline, Clomocycline, Demeclocycline, Doxycycline, Guamecycline, Lymecycline, Meclocycline, Methacycline, 35 Minocycline, Oxytetracycline, Penimepicycline, Pipacycline, Rolitetracycline, Sancycline, Senociclin and Tetracycline; and

others such as Cycloserine, Mupirocin, Tuberin.

**b. Synthetic Antibacterials**

2,4-Diaminopyrimidines such as Brodimoprim, Tetroxoprim and Trimethoprim;  
Nitrofurans such as Furaltadone, Furazolium, Nifuradene, Nifuratel, Nifurfoline,  
Nifurpirinol, Nifurpazine, Nifurtoinol and Nitrofurantoin;

5 Quinolones and analogs thereof, such as Amifloxacin, Cinoxacin, Ciprofloxacin,  
Difloxacin, Enoxacin, Fleroxacin, Flumequine, Lomefloxacin, Miloxacin, Nalidixic Acid,  
Norfloxacin, Ofloxacin, Oxolinic Acid, Perfloxacin, Pipemidic Acid, Piromidic Acid,  
Rosoxacin, Temafloxacin and Tosufloxacin;

Sulfonamides such as Acetyl Sulfamethoxypyrazine, Acetyl Sulfisoxazole,  
10 Azosulfamide, Benzylsulfamide, Chloramine-β, Chloramine-T, Dichloramine-T,  
Formosulfathiazole, N<sup>2</sup>-Formyl-sulfisomidine, N<sup>4</sup>-β-D-Glucosylsulfanilamide, Mafenide, 4'-  
(Methyl-sulfamoyl)sulfanilamide, p-Nitrosulfathiazole, Noprylsulfamide,  
Phthalylsulfacetamide, Phthalylsulfathiazole, Salazosulfadimidine, Succinylsulfathiazole,  
Sulfabenzamide, Sulfacetamide, Sulfachlorpyridazine, Sulfachrysoidine, Sulfacytine,  
15 Sulfadiazine, Sulfadiazine, Sulfadimethoxine, Sulfadoxine, Sulfaethidole, Sulfaguanidine,  
Sulfaguanol, Sulfalene, Sulfaloxic Acid, Sulfamerazine, Sulfameter, Sulfamethazine,  
Sulfamethizole, Sulfamethomidine, Sulfamethoxazole, Sulfamethoxypyridazine,  
Sulfametrole, sulfamidochrysoidine, Sulfamoxole, Sulfanilamide,  
Sulfanilamidomethanesulfonic Acid Triethanolamine Salt, 4-Sulfanilamidosalicylic Acid,  
20 N<sup>4</sup>-Sulfanilylsulfanilamide, Sulfanilylurea, N-Sulfanilyl-3,4-xylamide, Sulfanitrin,  
Sulfaperine, Sulfaphenazole, Sulfaproxyline, Sulfapyrazine, Sulfapyridine, Sulfasomizole,  
Sulfasymazine, Sulfathiazole, Sulfathiourea, Sulfatolamide, Sulfisomidine and Sulfisoxazole;

Sulfones, such as Acedapsone, Acediasulfone, Acetosulfone, Dapsone,  
Diathymosulfone, Glucosulfone, Solasulfone, Succisulfone, Sulfanilic Acid, p-  
25 Sulfanilylbenzylamine, p,p'-sulfonyldianiline-N,N'digalactoside, Sulfoxone and  
Thiazolsulfone;

Others such as Clofoctol, Hexedine, Magainins, Methenamine, Methenamine  
Anhydromethylene-citrate, Methenamine Hippurate, Methenamine Mandelate, Methenamine  
Sulfosalicylate, Nitroxoline, Squalamine and Xibornol.

30

**c. Antifungal (antibiotics)**

Polyenes such as Amphotericin-B, Candicidin, Dermostatin, Filipin,  
Fungichromin, Hachimycin, Hamycin, Lucensomycin, Mepartricin, Natamycin, Nystatin,  
Pecilocin, Perimycin; and others, such as Azaserine, Griseofulvin, Oligomycins, Pyrrolnitrin,  
35 Siccanin, Tubercidin and Viridin.

**d. Antifungal (synthetic)**

Allylamines such as Naftifine and terbinafine;

Imidazoles such as Bifonazole, Butoconazole, Chlordantoin, Chlormidazole, Cloconazole, Clotrimazole, Econazole, Enilconazole, Finticonazole, Isoconazole, Ketoconazole, Miconazole, Omoconazole, Oxiconazole Nitrate, Sulconazole and Tioconazole;

Triazoles such as Fluconazole, Itraconazole, Terconazole;

Others such as Acrisorcin, Amorolfine, Biphenamine, Bromosalicylchloranilide, Buclosamide, Chlophenesin, Ciclopirox, Cloxyquin, Coparaffinate, Diamthazole, Dihydrochloride, Exalamide, Flucytosine, Halethazole, Hexetidine, Loflucarban, Nifuratel, Potassium Iodide, Propionic Acid, Pyrrhione, Salicylanilide, Sulbentine, Tenonitroazole, Tolciclate, Tolindate, Tolnaftate, Tricetin, Ujotion, and Undecylenic Acid.

**e. Antiglaucoma agents**

Antiglaucoma agents, such as Dapiprazole, Dichlorphenamide, Dipivefrin and Pilocarpine.

**f. Anti-inflammatory agents**

Corticosteroids, aminoarylcarboxylic Acid Derivatives such as Etofenamate, Meclofenamic Acid, Mefenamic Acid, Niflumic Acid;

Arylacetic Acid Derivatives such as Acemetacin, Amfenac, Cinmetacin, Clopirac, Diclofenac, Fenclofenac, Fenclorac, Fenclozic Acid, Fentiazac, Glucametacin, Isozepam, Lonazolac, Metiazinic Acid, Oxametacine, Proglumetacin, Sulindac, Tiaramide and Tolmetin;

Arylbutyric Acid Derivatives such as Butibufen and Fenbufen;

Arylcarboxylic Acids such as Clidanac, Ketorolac and Tinoridine;

Arylpropionic Acid Derivatives such as Bucloxic Acid, Carprofen, Fenoprofen, Flunoxaprofen, Ibuprofen, Ibuprofen, Oxaprozin, Piroxicam, Piroxicam, Pranoprofen, Protizinic Acid and Tiaprofenic Acid;

Pyrazoles such as Mepirizole;

Pyrazolones such as Clofezone, Feprazone, Mofebutazone, Oxyphenbutazone, Phenylbutazone, Phenyl Pyrazolidinones, Suxibuzone and Thiazolinobutazone;

Salicylic Acid Derivatives such as Bromosaligenin, Fendosal, Glycol Salicylate, Mesalamine, 1-Naphthyl Salicylate, Olsalazine and Sulfasalazine;

Thiazinecarboxamides such as Droxicam, Isoxicam and Piroxicam;

Others such as e-Acetamidocaproic Acid, S-Adenosylmethionine, 3-Amino-4-hydroxybutyric Acid, Amixetrine, Bendazac, Bucolome, Carbazones, Difenpiramide, Ditazol, Guaiazulene, Heterocyclic Aminoalkyl Esters of Mycophenolic Acid and Derivatives.

Nabumetone, Nimesulide, Orgotein, Oxaceprol, Oxazole Derivatives, Paranyline, Pifoxime, 2-substituted-4, 6-di-tertiary-butyl-s-hydroxy-1,3-pyrimidines, Proquazone and Tenidap.

**g. Antiseptics**

- 5 Guanidines such as Alexidine, Ambazone, Chlorhexidine and Picloxydine;  
 Halogens/Halogen Compounds such as Bornyl Chloride, Calcium Iodate, Iodine, Iodine Monochloride, Iodine Trichloride, Iodoform, Povidone-Iodine, Sodium Hypochlorite, Sodium Iodate, Symclosene, Thymol Iodide, Triclocarban, Triclosan and Troclosene Potassium;  
 10 Nitrofurans such as Furazolidone, 2-(Methoxymethyl)-5-Nitrofurran, Nidroxyzone, Nifuroxime, Nifurzide and Nitrofurazone;  
 Phenols such as Acetomerocetol, Chloroxylenol, Hexachlorophene, 1-Naphthyl Salicylate, 2,4,6-Tribromo-m-cresol and 3',4',5--Trichlorosalicylanilide;  
 Quinolines such as Aminoquinuride, Chloroxine, Chlorquinaldol, Cloxyquin,  
 15 Ethylhydrocupreine, Halquinol, Hydrastine, 8-Hydroxyquinoline and Sulfate; and  
 others, such as Boric Acid, Chloroazodin, m-Cresyl Acetate, Cupric sulfate and Ichthammol.

**h. Antivirals**

- 20 Purines/Pyrimidinones, such as 2-Acetyl-Pyridine 5-((2-pyridylamino)thiocarbonyl) Thiocarbonohydrazone, Acyclovir, Dideoxyadenosine, dideoxycytidine, Dideoxyinosine, Edoxudine, Floxuridine, Ganciclovir, Idoxuridine, MADU, Pyridinone, Trifluridine, Vidrarbine and Zidovudline;  
 Others such as Acetylleucine Monoethanolamine, Acridinamine,  
 25 Alkylisooxazoles, Amantadine, Amidinomycin, Cuminaldehyde Thiosemicarbazone, Foscarnet Sodium, Kethoxal, Lysozyme, Methisazone, Moroxydine, Podophyllotoxin, Ribavirin, Rimantadine, Stallimycin, Statolon, Thymosins, Tromantadine and Xenazoic Acid.

**Combinations and kits**

- 30 The compounds and compositions containing the compounds may also be coated on bandages, mixed with bioadhesives or included in dressings. Thus, combinations of bandages, bioadhesives, dressings and other such materials and the compositions formulated as described herein are provided. Kits containing these combinations, which may also include compositions containing the above listed agents, are also provided.

35

**Articles of manufacture**

The compounds and compositions provided herein may be packaged as articles of manufacture containing packaging material, one or more of the compounds provided herein,

which is effective for ameliorating peripheral hyperalgesia, within the packaging material, and a label that indicates that the compound, N-oxide, acid, salt or other derivative thereof is used for treating hyperalgesic conditions.

## 5 Methods of treatment

Compositions for use with human skin preferably may be applied at least once per day, or if necessary, to achieve the desired result, more often, to the areas of the skin for which treatment is sought. It is understood that the precise treatment regimen depends upon the individual treated and may be ascertained empirically depending upon the formulation, and particularly, the age of the treated individual. Any regimen is acceptable as long as the desired anti-hyperalgesic effects are achieved without substantial deleterious or sustained undesirable side effects.

The methods for treating human skin are practiced by applying to the skin, preferably at least daily, a composition suitable for human skin treatment or treatment of mucosal membranes and other body surface tissues, including the vagina, rectum, mouth, eyes and other such tissues. The compositions may be injected into joints or other inflamed areas.

Compositions may be combined with bandages, bioadhesives and other dressings and applied to the body in combination therewith.

The following examples are included for illustrative purposes only and are not intended to limit the scope of the invention.

### Example A - Capsules

Active Compound	2.5 gm
Corn starch	23.0 gm
25 Lactose	145.0 gm
Talc	15.0 gm
Magnesium stearate	3.0 gm

The ingredients were mixed and were encapsulated using techniques practiced in the art.

### Example B - Tablet

Active Compound	150 gm
Lactose	125 gm
35 Corn starch	50 gm
Magnesium stearate	2.0 gm
Liquid Petrolatum	2.0 gm



The ingredients were mixed, then put through U.S. Standard Screens to produce fine granules. The granules were compressed into tablets, each tablet containing about 150 mg of an active compound of the present invention.

5    Example C - Syrup

	Active Compound	25 gm
	Lemon Oil	2 ml
	Sucrose	650 gm
	Citric Acid	4 gm
10	Benzoic Acid	3 gm
	Tragacanth	16 gm
	Deionized water q.s.	1000 ml

15    The ingredients, without the active compound, are dispersed in water to make about 800 to 900 ml of solution. The active compound is then added and the solution is stirred into a syrup. Water is then added to make 1000 ml of the syrup.

20    Example D - Parenteral Solution

	Active Compound	30 gm
	Methylparaben	3 gm
	Propylparaben	1 gm
25	Lidocaine	5 gm
	Deionized water q.s.	1000 ml

30    The ingredients are dissolved in water to provide a solution followed by sterilization by filtration.

Example E - Rectal Suppository

	Active Compound	80 gm
35	Propylene glycol	95 gm
	Polyethylene glycol 4000	1800 gm

The active compound is added to the propylene glycol and milled until a finely divided uniform mixture is formed. The polyethylene glycol 4000 is melted and the propylene glycol dispersion is added with stirring to obtain a suspension. The suspension is poured into molds, allowed to solidify and removed from the molds for packaging.

5

Example F - Water-washable ointment

	Active Compound	1.4 % w/w
10	Lanolin alcohol	0.15 w/w
	Emulsifying wax NF	7.5% w/w
	PEG-20 glycerides	5.0% w/w
	Petrolatum	86.0% w/w

15        The ingredients are melted together and mixed well until the resulting ointment congeals.

Example G - Oil-in-water cream

20

	Active Compound	10.0% w/w
	Benzyl alcohol	4.0% w/w
	Propylene glycol	10.0% w/w
	Polyethylene glycol 400	10.0% w/w
25	Petrolatum	20.0% w/w
	Stearyl alcohol	10.0% w/w
	Poloxamer	10.0% w/w
	Water q.s.	100
	Buffer to pH	7.0% w/w

30

In preparing the oil-in-water cream, water, propylene glycol and polyethylene glycol 400 are heated to about 70 to 80°C, followed by adding a mixture of petrolatum, stearyl alcohol and poloxamer and the mixture is stirred until homogeneous. The active compound in benzyl alcohol is added and the mixture is homogenized. The pH is then adjusted with a buffer to about 7.0.

40

Example H - Aqueous gel

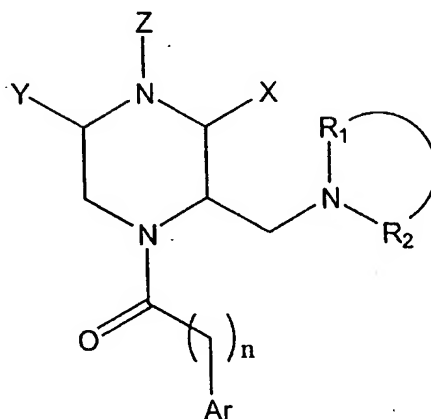
	Active Compound	10.0% w/w
	Benzyl alcohol	4.0% w/w
5	Hydroxyethyl cellulose	3.0% w/w
	Water q.s.	100
	Buffer to pH	7.0% w/w

10       The aqueous gel is prepared by mixing the active compound, benzyl alcohol and adding the mixture to buffered water. Hydroxyethyl cellulose is then added with stirring until the mixture gels.

15       Having described the invention with reference to its preferred embodiments, it is to be understood that modifications within the scope of the invention will be apparent to those skilled in the art.

**WHAT IS CLAIMED IS:**

1. A compound of the formula I or a pharmaceutically acceptable salt thereof



(I)

5

wherein

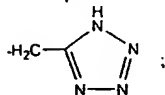
 $n = 1-3$ ;

$R_1$  and  $R_2$  are independently =  $\text{CH}_3$ ;  $-(\text{CH}_2)_m$ , where  $m = 4-8$ ,  $-\text{CH}_2\text{CH}(\text{OH})(\text{CH}_2)_2-$ ;  $-\text{CH}_2\text{CH}(\text{F})(\text{CH}_2)_2-$ ;  $-(\text{CH}_2)_2\text{O}(\text{CH}_2)_2-$ ; or  $-(\text{CH}_2)_2\text{CH}=\text{CHCH}_2-$ ;

$\text{Ar} =$  unsubstituted or mono-, or di-substituted phenyl wherein said substituents are selected from the group consisting of halogen,  $\text{OCH}_3$ ,  $\text{SO}_2\text{CH}_3$ ,  $\text{CF}_3$ , amino, alkyl, and 3,4-dichloro; benzothiophenyl; benzofuranyl; naphthyl; diphenyl methyl; or 9-fluorene;

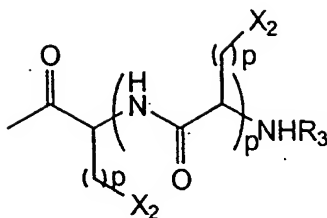
Z is

- 10  $-\text{P}(\text{O})(\text{OBn})_2$ ;  $-\text{P}(\text{O})(\text{OH})_2$ ;  $-(\text{CH}_2)_p\text{C}(\text{O})\text{NHOH}$ ;  $-(\text{CH}_2)_p\text{CO}_2\text{H}$ ;  $-\text{SO}_2\text{CH}_3$ ;  $-\text{SO}_2\text{NH}_2$ ;  $-\text{CO}(\text{CH}_2)_p\text{CH}(\text{NH}_2)(\text{CO}_2\text{H})$ ;  $-\text{COCH}(\text{NH}_2)(\text{CH}_2)_p\text{CO}_2\text{H}$ ;  $-\text{CO}_2\text{CH}_3$ ;  $-\text{CONH}_2$ ;  $-(\text{CH}_2)_p\text{O}(\text{CH}_2)_p\text{CO}_2\text{H}$ ;  $-(\text{CH}_2)_p\text{O}(\text{CH}_2)_p\text{CONHOH}$ ;  $-(\text{CH}_2)_p\text{NH}\text{SO}_2\text{CH}_3$ ;  $-(\text{CH}_2)_p\text{NHC}(\text{S})\text{NHCH}(\text{CO}_2\text{H})(\text{CH}_2)_p\text{CO}_2\text{H}$ ;  $-(\text{CH}_2)_p\text{SO}_3\text{H}$ ; or



15

or Z is



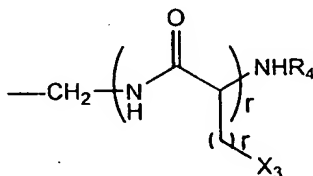
wherein

- 5       $p = 0-20$ ;  
        $R_3 = -H$  or  $-Ac$ ;  
        $X_2 = -CO_2H$ ;  $-NHSO_2CH_3$ ;  $NHP(O)(OBn)_2$ ;  $NHP(O)(OH)_2$ ;  
        $-OP(O)(OBn)_2$ ; or  $OP(O)(OH)_2$ ;

X and Y are independently

- $-CH_2NHSO_2CH_3$ ,  $-CH_2NHP(O)(OBn)_2$ ,  $-CH_2NHP(O)(OH)_2$ ,  $-CH_2OP(O)(OBn)_2$ ,  
 $-CH_2OP(O)(OH)_2$ ,  $-(CH_2)_qO(CH_2)_qCO_2H$ ,  $-(CH_2)_qO(CH_2)_qSO_3H$ ,  
 $-(CH_2)_qO(CH_2)_qCHNHOH$ ,  
 $-CH_2NHC(S)NHCH(CO_2H)(CH_2)_qCO_2H$ , or

10



wherein

- $q = 1-20$   
 $r = 1-20$   
 $R_4 = -H$  or  $-Ac$   
 $X_3 = -CO_2H$ ;  $-NHSO_2CH_3$ ;  $-NHP(O)(OBn)_2$ ;  
 $-NHP(O)(OH)_2$ ;  $-OP(O)(OBn)_2$ ; or  
 $-OP(O)(OH)_2$

15

2. A compound according to claim 1 selected from the group consisting of:

20 Methyl-4-[-2-glycyl-4-(trifluoromethylphenyl)acetyl]-3-(R,S)-[(1-pyrrolidiny)-methyl]-1-piperazinecarboxylate;

Methyl-4-[(2-[N,N-bis-methylsulfonamido]-4-trifluoromethylphenyl)acetyl]-3-(R,S)-[(1-pyrrolidiny)-methyl]-1-piperazinecarboxylate dihydrochloride;

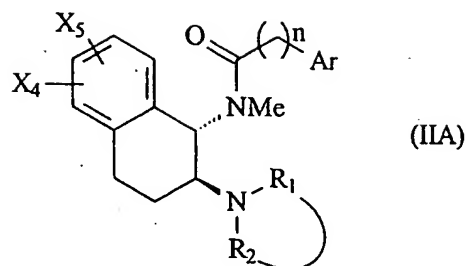
25 Methyl-4-[(2-[N-methylsulfonamido]phenyl)acetyl]-3-(R,S)-[(1-pyrrolidiny)methyl]-1-piperazinecarboxylate hydrochloride;

- Methyl-4-[(2-[N,N-bis-methylsulfonamido]phenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl) methyl]-1-piperazinecarboxylate hydrochloride;
- 5 Methyl-4-[(2-[N-methylamino)sulfamyl]phenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl) methyl]-1-piperazinecarboxylate hydrochloride;
- Methyl-4-[-4-[N-methylamino)sulfamyl]phenyl)acetyl]-3-(R,S)-[(1-pyrrolidinyl) methyl]-1-piperazinecarboxylate hydrochloride;
- 10 4-Trifluoroacetyl-1-[(trans-3-furanacyrlate]-2-(R,S)-(1-pyrrolidinyl)methyl] piperazine hydrochloride;
- 4-Trifluoroacetyl-1-[-(4-trifluoromethyl)phenyl)acetyl]-2-(R,S)-(1-pyrrolidinyl) methyl] piperazine hydrochloride;
- 15 Methyl-4-[(3,4-dichlorophenyl)acetyl]-3-(R,S)-[(4'-methylpiperazinecarboxylate)methyl]-1-piperazinecarboxylate hydrochloride;
- 20 Methyl-4-[(4-a,a,a-trifluoromethylphenyl)acetyl]-3-(R,S)-[3-(S)-(4'-a,a,a-trifluoromethylphenylacetate)-1-(pyrrolidinyl)methyl]-1-piperazinecarboxylate hydrochloride;
- Methyl-4-[(3,4-dichlorophenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidinemethyl-3',4'-dichlorophenyl acetate)methyl]-1-piperazinecarboxylate hydrochloride;
- 25 Methyl-4-[(3,4-dichlorophenyl)acetyl]-3-(R)-[(2-(S)-pyrrolidinemethanol)methyl]-1-piperazinecarboxylate hydrochloride;
- Methyl-4-[(2-nitro-4-a,a,a-trifluoromethylphenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidine methanol)methyl]-1-piperazinecarboxylate hydrochloride;
- 30 Methyl-4-[(4-methylsulphonylphenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidinemethyl-4'-methylsulphonylphenylacetate)methyl]-1-piperazinecarboxylate hydrochloride;
- 35 Methyl-4-[(4-methylsulphonylphenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidinemethanol) methyl]-1-piperazinecarboxylate hydrochloride;
- Methyl-4-[(2-amino-4-a,a,a-trifluoromethylphenyl)acetyl]-3-(R,S)-[(2-(S)-pyrrolidine methanol)methyl]-1-piperazinecarboxylate hydrochloride;
- 40 Methyl-4-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[3-(S)-(3',4'-dichlorophenyl acetate)-1-(pyrrolidinyl)methyl]-1-piperazinecarboxylate hydrochloride;
- 4-Acetyl-1-[3-(N-methylsulfonamido)phenyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl) methyl]piperazine hydrochloride;
- 45 4-Acetyl-1-[(2-acetylamidophenyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl] piperazine hydrochloride;

- 4-Acetyl-1-[(4-acetylamidophenyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl] piperazine hydrochloride;
- 5 4-Acetyl-1-[(4-methylsulfonyl]phenyl)acetyl]-2-(R,S)-[3-(S)-(4'-methylsulfonyl phenyl acetate)-1-(pyrrolidinyl)methyl] piperazine hydrochloride;
- 4-Acetyl-1-[(4-a,a,a-trifluoromethylphenyl)acetyl]-2-(R,S)-[3-(S)- (4'-a,a,a trifluoro methylphenyl acetate)-1-(pyrrolidinyl)methyl]piperazine hydrochloride;
- 10 4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[3-(S)-(3',4'-dichlorophenyl acetate)-1-(pyrrolidinyl)methyl]piperazine hydrochloride;
- 4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[(2-(S)-pyrrolidinemethyl-3',4' dichlorophenylacetate)methyl]piperazine hydrochloride;
- 15 4-Acetyl-1-[(4-trifluoromethylphenyl)acetyl]-2-(R,S)-[2-(S)-pyrrolidinemethyl-4'-trifluoromethylphenylacetate)methyl]piperazine hydrochloride;
- 20 4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[(2-(S)-pyrrolidinemethanol) methyl]piperazine hydrochloride;
- 4-Acetyl-1-[(4-methylsulphonylphenyl)acetyl]-2-(R,S)-[(2-(S)-pyrrolidinemethyl-4'-methylsulphonylphenylacetate)methyl]piperazine hydrochloride;
- 25 4-Acetyl-1-[(4-methylsulphonylphenyl)acetyl]-2-(R,S)-[(2-(S)-pyrrolidinemethanol) methyl]piperazine hydrochloride;
- 4-Acetyl-1-[(4-trifluoromethylphenyl)acetyl]-2-(R,S)-[(2-(S)-pyrrolidinemethanol) methyl]piperazine hydrochloride;
- 30 4-Formyl-1-[(2-N-methylsulfamylphenyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl] piperazine hydrochloride;
- 35 4-Carbonylimidazole-1-[(3,4-dichlorophenyl)acetyl]-2-(R)-[(1-pyrrolidinyl)methyl] piperazine hydrochloride;
- 4-Allyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R)-[(1-pyrrolidinyl)methyl]piperazine hydrochloride
- 40 4-Acetyl-1-[(2-pyridyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl]piperazine hydrochloride;
- 4-Formyl-1-[(2-pyridyl)acetyl]-2-(R,S)-[(1-pyrrolidinyl)methyl]piperazine hydrochloride;
- 45 Methyl-4-[(3,4-dichlorophenyl)acetyl]-3-(S)-[(2-(S)-pyrrolidinemethanol)methyl]-1-piperazinecarboxlate hydrochloride;

- 4-Methanesulfonyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[3-(S)-methanesulfonate-1-(pyrrolidinyl)methyl]piperazine hydrochloride;
- 5 4-Methylsulphonyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[3-(S)-(3',4'-dichlorophenyl acetate)-1-(pyrrolidinyl)methyl]piperazine hydrochloride;
- 4-Methylsulphonyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R,S)-[(3-(S)-hydroxy-1-pyrrolidinyl)methyl]piperazine hydrochloride;
- 10 4-Methylsulphonyl-1-[(4- $\alpha,\alpha,\alpha$ -trifluoromethylphenyl)acetyl]-2-(R,S)-[3-(S)-(4'- $\alpha,\alpha,\alpha$ -trifluoromethylphenyl acetate)-1-(pyrrolidinyl)methyl]piperazine hydrochloride; and
- 4-Methylsulphonyl-1-[(4- $\alpha,\alpha,\alpha$ -trifluoromethylphenyl)acetyl]-2-(R,S)-[(3-(S)-hydroxy-1-pyrrolidinyl)methyl]piperazine hydrochloride.
- 15 4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(S)-[(3'-(S)-hydroxy-1-pyrrolidine)methyl]-piperazine hydrochloride
- 4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(R)-[(3'-(R)-hydroxy-1-pyrrolidine)methyl]-piperazine hydrochloride
- 20 4-Acetyl-1-[(3,4-dichlorophenyl)acetyl]-2-(S)-[(3'-(R)-hydroxy-1-pyrrolidine)methyl]-piperazine hydrochloride
- 25 3. A pharmaceutical composition comprising a compound of claim 2 in a pharmaceutically acceptable carrier.
4. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of a compound of claim 2.
- 30 5. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of the pharmaceutical composition of claim 3.
- 35 6. A pharmaceutical composition comprising a compound of claim 2 and an antibiotic, antiviral, antifungal, anti-inflammatory agent or a mixture thereof in a pharmaceutically acceptable carrier.
7. A compound of the formula IIA or a pharmaceutically acceptable salt thereof
- 40





wherein

$n=1-3$ ,

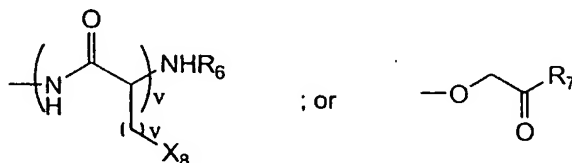
- 5  $R_1$  and  $R_2$  are independently =  $\text{CH}_3$ ;  $-(\text{CH}_2)_m$ , where  $m=4-8$ ,  
 $-\text{CH}_2\text{CH}(\text{OR})(\text{CH}_2)_2-$  wherein  $R$  is  $\text{H}$ , alkyl, acyl or aryl;  $\text{CH}_2\text{CH}(\text{F})(\text{CH}_2)_2-$ ;  
 $-(\text{CH}_2)_2\text{O}(\text{CH}_2)_2-$ ; or  $-(\text{CH}_2)_2\text{CH}=\text{CHCH}_2-$ ;  
 $\text{Ar}$  = mono- or di-substituted phenyl; wherein said substituents are selected  
 10 from the group consisting of halogen,  $\text{OCH}_3$ ,  $\text{OH}$ ,  $\text{SO}_2\text{CH}_3$ ,  $\text{CF}_3$ ,  $\text{NH}_2$ , alkyl,  
 $\text{CN}$ , unsubstituted and substituted sulfamoyl groups;  
 or  $\text{Ar}$  substituted with  
 $-\text{NH}(\text{CH}_2)_u\text{CO}_2\text{R}'$ ;  $-\text{NH}(\text{CH}_2)_u(\text{CH}=\text{CH})_u(\text{CH}_2)\text{CO}_2\text{R}'$ ;  
 $-\text{NHCO}(\text{CH}_2)_u(\text{CH}=\text{CH})_u(\text{CH}_2)_u\text{CO}_2\text{R}'$ ;  $-\text{NHP}(\text{O})(\text{OBn})_2$ ;  $-\text{NHP}(\text{O})(\text{OR}')_2$ ;  
 $-(\text{CH}_2)_u\text{NHSO}_2\text{CH}_3$ ;  $-(\text{CH}_2)_u\text{NHC}(\text{S})\text{NHCH}(\text{CO}_2\text{R}')(\text{CH}_2)_u\text{CO}_2\text{R}'$ ;  
 15  $-\text{CONHOH}$ ; or  $-(\text{CH}_2)_u\text{CONHOH}$ ;

wherein

$u = 0-5$ ;

$\text{R}' = \text{H}$  or lower alkyl;

20 or  $\text{Ar}$  is



$\text{R}_6 = -\text{H}$  or  $-\text{Ac}$

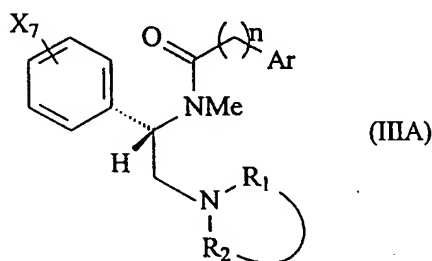
$\text{X}_8 = -\text{CO}_2\text{H}$ ;  $-\text{NHSO}_2\text{CH}_3$ ;  $-\text{NHP}(\text{O})(\text{OBn})_2$ ;  
 $-\text{NHP}(\text{O})(\text{OH})_2$ ;  $-\text{OP}(\text{O})(\text{OBn})_2$ ; or  
 $-\text{OP}(\text{O})(\text{OH})_2$ ;

$\text{R}_7 = -\text{NH}(\text{CH}_2)_v\text{CO}_2\text{H}$ ;  $-\text{NH}(\text{CH}_2)_v\text{CH}(\text{NH}_2)(\text{CO}_2\text{H})$ ;  
 $-\text{NHCH}(\text{CO}_2\text{H})(\text{CH}_2)_v\text{NH}_2$ ;  $-\text{NH}(\text{CH}_2)_v\text{SO}_3\text{H}$ ;  
 $-\text{NH}(\text{CH}_2)_v\text{PO}_3\text{H}_2$ ;  $-\text{NH}(\text{CH}_2)_v\text{NHC}(\text{NH})\text{NH}_2$ ; or  
 $-\text{NHCH}(\text{CO}_2\text{H})(\text{CH}_2)_v\text{CO}_2\text{H}$ ; and  
 $v = 1-20$ .

25  $\text{X}_4$  and  $\text{X}_5$  are independently  $\text{H}$ ; halogen;  $\text{OH}$ ;  $\text{OCH}_3$ ;  $\text{CF}_3$ ;  $\text{NO}_2$ ;  $\text{NH}_2$ ; amino substituted  
 with acyl, carbamate, alkyl or aryl sulfonates;  $\text{COR}'$  where  $\text{R}'$  is  $\text{OH}$ , amide, alkoxy, aryloxy  
 or heteroaryloxy.

8. A pharmaceutical composition comprising a compound of claim 7 in a  
 pharmaceutically acceptable carrier.

9. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of a compound of claim 7.
10. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of the pharmaceutical composition of claim 8.
11. A pharmaceutical composition comprising a compound of claim 7 and an antibiotic, antiviral, antifungal, anti-inflammatory agent or a mixture thereof in a pharmaceutically acceptable carrier.
12. A compound of the formula IIIA or a pharmaceutically acceptable salt thereof



15

wherein

 $n=1-3$ ; $R_1$  and  $R_2$  are independently  $=CH_3$ ;  $-(CH_2)_m$ , wherein  $m=4-8$ ; $-CH_2CH(OR)(CH_2)_2-$ , wherein  $R=H$ , alkyl, acyl or aroyl;20  $CH_2CH(F)(CH_2)_2-$ ;  $-(CH_2)_2O(CH_2)_2-$ ; or  $-(CH_2)_2CH=CHCH_2-$ ;Ar = mono- or di-substituted phenyl; wherein said substituents are selected from the group consisting of halogen,  $OCH_3$ ,  $OH$ ,  $SO_2CH_3$ ,  $CF_3$ ,  $NH_2$ , alkyl, CN, unsubstituted and substituted sulfamoyl groups;

Ar may also be substituted with

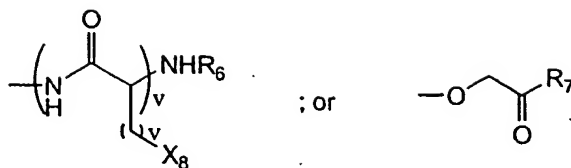
25  $-NH(CH_2)_uCO_2R'$ ;  $-NH(CH_2)_u(CH=CH)_u(CH_2)CO_2R'$ ; $-NHCO(CH_2)_u(CH=CH)_u(CH_2)_uCO_2R'$ ;  $-NHP(O)(OBn)_2$ ;  $-NHP(O)(OR')_2$ ; $-(CH_2)_uNH SO_2CH_3$ ;  $-(CH_2)_uNHC(S)NHCH(CO_2R')(CH_2)_uCO_2R'$ ; $-CONHOH$ ; or  $-(CH_2)_uCONHOH$ ;

wherein

30

 $u = 0-5$ ; $R' = H$  or lower alkyl;

or Ar is



$R_6 = -H$  or  $-Ac$

$X_8 = -CO_2H$ ;  $-NHSO_2CH_3$ ;  $-NHP(O)(OBn)_2$ ;  
 $-NHP(O)(OH)_2$ ;  $-OP(O)(OBn)_2$ ; or  
 $-OP(O)(OH)_2$ ;

$R_7 = -NH(CH_2)_vCO_2H$ ;  $-NH(CH_2)_vCH(NH_2)(CO_2H)$ ;  
 $-NHCH(CO_2H)(CH_2)_vNH_2$ ;  $-NH(CH_2)_vSO_3H$ ;  
 $-NH(CH_2)_vPO_3H_2$ ;  $-NH(CH_2)_vNHC(NH)NH_2$ ; or  
 $-NHCH(CO_2H)(CH_2)_vCO_2H$ ; and  
 $v = 1-20$ .

$X_7$  is H; halogen; OH;  $OCH_3$ ;  $CF_3$ ;  $NO_2$ ;  $NH_2$ ; amino substituted with acyl, carbamate, alkyl or aryl sulfonates; COR' where R' is OH, amide, alkoxy, aryloxy or heteroaryloxy.

13. The compound according to claim 12 selected from the group consisting of:

10 N-[(4-Trifluoromethylphenyl)-N-methyl-N-[[1S]-1-phenyl-2-[1-pyrrolidinyl]ethyl]acetamido] glycine hydrochloride;

2-(3,4-Dichlorophenyl)-N-methyl-N-[(1R, S)-1-(3-sulfamidophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride;

15 2-(4-Trifluoromethylphenyl)-N-methyl-N-[[1S]-1-[3-[(methylsulfonyl)amino]phenyl]-2-[1-pyrrolidinyl]ethyl]acetamide hydrochloride (2d);

2-(4-Methanesulfonylphenyl)-N-methyl-N-[[1S]-1-[3-[(methylsulfonyl)amino]phenyl]-2-[1-pyrrolidinyl]ethyl]acetamide methanesulfonate;

20 2-(3,4-Dichlorophenyl)-N-methyl-N-[[1S]-1-[3-[(methylsulfonyl)amino]phenyl]-2-[1-pyrrolidinyl]ethyl]acetamide hydrochloride;

25 2-(3,4-Dichlorophenyl)-N-methyl-N-[(1S)-1-[3-(diethyl phosphoryl)amino]phenyl]-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride;

2-(3,4-Dichlorophenyl)-N-methyl-N-[(1S)-1-[3-[(4-oxo-butenate)]amino]phenyl]-2-(1-pyrrolidinyl)ethyl]acetamide;

30 2-(3,4-Dichlorophenyl)-N-methyl-N-[(1S)-1-[3-(3-(((iso-butoxycarbonyl)-methyl)aminocarbonyl)propionamido)phenyl]-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride;

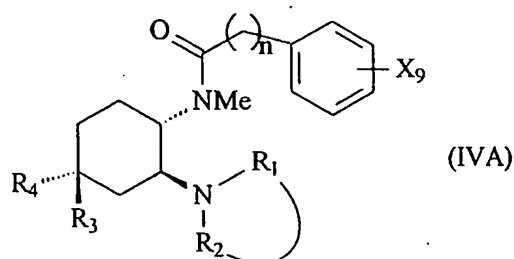
35 2-(3,4-Dichlorophenyl)-N-methyl-N-[(1R, S)-1-[3-(3-(((hydroxycarbonyl)-methyl)aminocarbonyl)propionamido)phenyl]-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride;

- 2-[(2-N-Phenylsulfonamido)-phenyl]-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamide methane sulfonate;
- 5 2-[3-(N-Methylsulfamoyl)-4-chlorophenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl] acetamide hydrochloride;
- 2-(3-Sulfamoyl-4-chlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl] acetamide methanesulfonate;
- 10 2-(3-Sulfamoyl-4-chlorophenyl)-N-methyl-N-[(1S)-1-[3-[(methylsulfonyl)amino]phenyl]-2-[1-pyrrolidinyl]ethyl] acetamide methanesulfonate;
- 2-[3-(N-Methylsulfamoyl)-4-fluorophenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl] acetamide hydrochloride;
- 15 2-[2&4-(N-Methylsulfamoyl)-phenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl] acetamide hydrochloride
- 3-(N-Methylsulfamoyl)-phenyl-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamide hydrochloride
- 20 2-[N-Methylsulfamoyl]-4-bromo-phenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl] acetamide hydrochloride
- 25 2-[2&4-(N-Methylsulfamoyl)phenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-(3S)-3-hydroxypyrrolidinyl]ethyl] acetamide hydrochloride;
- 2-[2-Methoxy-3-(N-methylsulfamoyl)phenyl]-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamide hydrochloride;
- 30 (Z)-4-[2-(2-Aminophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-(3S)-3-hydroxypyrrolidinyl]-ethyl]acetamido]4-oxo-2-butenic acid;
- (Z)-4-[2-(2-Amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]ethyl]acetamido]4-oxo-butanoic acid;
- 35 (Z)-4-[2-(2-Amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]-ethyl]acetamido]4-oxo-2-butenic acid;
- (E) Ethyl 4-[2-(2-amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]ethyl]acetamido]4-oxo-2-butenate hydrochloride;
- 40 (Z)-4-[2-(2-Amino-4-trifluoromethylphenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]-ethyl]acetamido]4-oxo-2-butenic acid;
- 45 (Z)-4-[2-(2-Aminophenyl)-N-methyl-N-[(1S)-1-phenyl]-2-[1-pyrrolidinyl]-ethyl]acetamido]4-oxo-2-butenic acid hemimaleate;

- 2-(N,N-Bisacetic acid-2-amino- $\alpha,\alpha,\alpha$ -trifluoro-4-tolyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride;
- 5 3-[2-N-Methylsulfonamido)-phenyl]-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride
- 2-(O-Butylacetate)-phenyl-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl acetamide hydrochloride
- 10 2-[Phenoxy-acetyl]methylamino-(1-pyrrolidinyl) ethyl]acetamide]hydrochloride
- 2-[4-Trifluoromethylphenyl]-N-methyl-N-[(1S)-1-phenyl-2-[1-(3S)-3-hydroxy-pyrrolidinyl]ethyl] acetamide hydrochloride;
- 15 2-(2-Pyridyl)-N-methyl-N-[(1S)-1-phenyl-2-[1-(3S)-3-hydroxy-pyrrolidinyl]ethyl] acetamide dihydrochloride;
- 2-(5-Bromo-3-pyridyl)-N-methyl-N-[(1S)-1-phenyl-2-pyrrolidinyl ethyl]acetamide hydrochloride;
- 20 2-(5-Bromo-3-pyridyl)-N-methyl-N-[(1S)-1-phenyl-2-[1-(3S)-3-hydroxy-pyrrolidinyl]ethyl] acetamide hydrochloride;
- 25 2-(9-Anthracenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamide hydrochloride;
- 2-(2-Carboxyphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamide hydrochloride;
- 30 [2-(2-Phenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamido]2-oxo-glycine hydrochloride;
- Methyl N-[2-(2-phenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamido]2-oxo-glycinate hydrochloride;
- 35 2-(3,4-Dihydroxyphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamide hydrochloride;
- 40 2-(3,4-Dimethoxyphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl] acetamide hydrochloride;
- 2-(2-Methanesulfonamidophenyl)-N-methyl-N-[(1S)-1-(3-methanesulfon-amidophenyl)-2-(1-pyrrolidinyl)ethyl]acetamide Hydrochloride;
- 45 2-(2-Iso-butyramidophenyl)-N-methyl-N-[(1S)-1-(3-isobutyramido-phenyl)-2-(1-pyrrolidinyl)ethyl]acetamide Methanesulfonic acid salt.;

- 4-[4-N-Methylsulfonamido-phenyl]-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)-ethyl]acetamide hydrochloride
- 5 2-(3,4-Dichlorocinnamyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)-ethyl]acetamide hydrochloride
- 2-(2-Nitrocinnamyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride
- 10 (R,S)-1-[2-(Methanesulfonylamino)phenyl-N-methylacetamido]-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane, methanesulfonic acid salt
- (R,S)-1-[2-(Methanesulfonylamino)phenyl-N-methylacetamido]-1-(3-hydroxyphenyl)-2-(1-pyrrolidino)-ethane, methanesulfonic acid salt
- 15 2-(3-Indolyl)-N-methyl-N-[(1S)-1-phenyl-2-[(3S)-1-pyrrolidin-3-ol]ethyl]-acetamide hydrochloride
- 2-(2-N-Benzyl-2-N-methylsulfamoyl--3,4-dimethoxyphenyl)-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride
- 20 2-(N-Methylsulfonamido-2-aminophenyl)-N-methyl-N-[(1R)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide methane sulfonate
- (R,S)-1-(4-Trifluoromethylphenyl-N-methylacetamido)-1-(3-methoxyphenyl)-2-(1-pyrrolidino)-ethane, methanesulfonic acid salt
- 25 (R,S)-1-(4-Trifluoromethylphenyl-N-methylacetamido)-1-(3-hydroxyphenyl)-2-(1-pyrrolidino)-ethane, methanesulfonic acid salt
- 2-Fluorophenyl-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]-acetamide hydrochloride
- 30 4-Fluorophenyl-N-methyl-N-[(1S)-1-phenyl-2-(1-pyrrolidinyl)ethyl]acetamide hydrochloride (3ccc)
- (E)-4-[2-(2-Amino-4,5-dichlorophenyl)-N-methyl-N-[(1S)-1-phenyl-2-[1-pyrrolidinyl]ethyl]acetamido]4-oxo-2-butenic acid hydrochloride
- 35
14. A pharmaceutical composition comprising a compound of claim 12 in a pharmaceutically acceptable carrier.
- 40 15. A pharmaceutical composition comprising a compound of claim 13 in a pharmaceutically acceptable carrier.

16. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of a compound of claim 12.
17. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of a compound of claim 13.
18. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of the pharmaceutical composition of claim 14.
19. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of the pharmaceutical composition of claim 15.
20. A pharmaceutical composition comprising a compound of claim 12 and an antibiotic, antiviral, antifungal, anti-inflammatory agent or a mixture thereof in a pharmaceutically acceptable carrier.
21. A pharmaceutical composition comprising a compound of claim 13 and an antibiotic, antiviral, antifungal, anti-inflammatory agent or a mixture thereof in a pharmaceutically acceptable carrier.
22. A compound of the formula IVA or a pharmaceutically acceptable salt thereof



wherein

$n=1-3$ ;

$R_1$  and  $R_2$  are independently  $=CH_3$ ;  $-(CH_2)_m$ , where  $m=4-8$ ;

$-CH_2CH(OR)(CH_2)_2-$ , wherein  $R = H$ , alkyl, acyl, or aroyl;

$CH_2CH(F)(CH_2)_2-$ ;  $-(CH_2)_2O(CH_2)_2-$ ; or  $-(CH_2)_2CH=CHCH_2-$ ;

$R_3$  and  $R_4$  are independently  $H$ ;  $OCH_3$ ; alkyl; or  $-O(CH_2)_2$ ;

$X_9 = 1-4$  substituents selected from the groups consisting of

-halogen;  $-CF_3$ ;  $OH$ ;  $-OCH_3$ ;  $-SO_2NH(CH_2)_qCH_3$ ;  $-NH(CH_2)_qCOR'$ ;

$-NH(CH_2)_q(CH=CH)_q(CH_2)_qCO_2R'$ ;  $-NH(CH)_q(CH\equiv CH)_q(CH)_qCO_2R$ ;

$-NHCO(CH_2)_q(CH=CH)_q(CH_2)_qCO_2R$ ; and  $-NHCO(CH)_q(CH=CH)_q(CH)_qCO_2R'$ ;

wherein

q = 0-20 and

R' = OH, lower alkyl, aryl ester or aryl amide.

5 23. The compound according to claim 22 selected from the group consisting of:

(Z)-4-[2-((±)-trans-2-Amino-4,5-dichloro-N-methyl-N-[2-(1-pyrrolidinyl)-cyclohexyl]phenylaetamido)]4-oxo-2-butenic acid;

10 (Z)-4-[2-((±)-trans-2-Amino-4-trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)-cyclohexyl]-phenylaetamido)]4-oxo-2-butenic acid;

(±)-trans-2-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-pyridylacetamide dihydrochloride;

15 (±)-trans-3-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-5-bromo-pyridylacetamide hydrochloride;

(±)-trans-3,5-Di-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide hydrochloride;

20 (±)-trans-3-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-(trans-3-furyl)acetamide hydrochloride;

25 (±)-trans-2-Methoxy-3-methylsulfamoyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]phenylacetamide hydrochloride;

(±)-trans-3-N-Methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]indoleacetamide hydrochloride;

30 (±)-trans-4-Fluoro-3-methylsulfamoyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]phenylacetamide hydrochloride;

N-[1S, 2S-trans-4-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamido]glycine Hydrochloride;

35 N-[1R, 2R-trans-4-Trifluoromethyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamido]glycine hydrochloride; and

(±)-trans-4-Fluoro-3-methylsulfamoyl-N-methyl-N-[2-(1-pyrrolidinyl)cyclohexyl]-phenylacetamide hydrochloride.

40

24. A pharmaceutical composition comprising a compound of claim 22 in a pharmaceutically acceptable carrier.



25. A pharmaceutical composition comprising a compound of claim 23 in a pharmaceutically acceptable carrier.
26. A method of treating hyperalgesia in a patient comprising administering to said  
5 patient an effective amount of a compound of claim 22.
27. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of a compound of claim 23.
- 10 28. A method of treating hyperalgesia in a patient comprising administering to said patient an effective amount of the pharmaceutical composition of claim 24.
29. A method of treating hyperalgesia in a patient comprising administering to said  
15 patient an effective amount of the pharmaceutical composition of claim 25.
30. A pharmaceutical composition comprising a compound of claim 22 and an antibiotic, antiviral, antifungal, anti-inflammatory agent or a mixture thereof in a pharmaceutically acceptable carrier.
- 20 31. A pharmaceutical composition comprising a compound of claim 23 and an antibiotic, antiviral, antifungal, anti-inflammatory agent or a mixture thereof in a pharmaceutically acceptable carrier.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US99/13680

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(7) : C07D 207/04, 207/06, 401/10; A61K 31/40

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
NONEElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EAST, WEST**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,065,573 A (LEDNICER) 27 December 1977, see entire document.	1-31

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

## \* Special categories of cited documents:

\*A\* document defining the general state of the art which is not considered to be of particular relevance

\*B\* earlier document published on or after the international filing date

\*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

\*O\* document referring to an oral disclosure, use, exhibition or other means

\*P\* document published prior to the international filing date but later than the priority date claimed

\*T\*

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\*

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\*

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

\*A\*

document member of the same patent family

Date of the actual completion of the international search

03 NOVEMBER 1999

Date of mailing of the international search report

87 JAN 2000

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

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JOSEPH K. MCKANE

Telephone No. (703) 308-0196

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US99/13680

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US99/13680

## A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

514/85, 91, 255, 424, 429, 617, 618, 619, 620, 621, 622; 544/106, 111, 168, 337, 358, 359, 360, 373, 383, 386, 387, 389; 546/276.4; 548/413, 465, 517, 527, 541, 556, 568, 578, 579; 564/162, 163, 169, 170, 182

## B. FIELDS SEARCHED

Minimum documentation searched

Classification System: U.S.

514/85, 91, 255, 424, 429, 617, 618, 619, 620, 621, 622; 544/106, 111, 168, 337, 358, 359, 360, 373, 383, 386, 387, 389; 546/276.4; 548/413, 465, 517, 527, 541, 556, 568, 578, 579; 564/162, 163, 169, 170, 182

## BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claim(s) 1-6, drawn to piperazine compounds of Formula I, pharmaceutical compositions, and methods of use.

Group II, claim(s) 7-11, drawn to compounds of Formula 2A, pharmaceutical compositions, and methods of use.

Group III, claim(s) 12-21, drawn to compounds of Formula 3A, pharmaceutical compositions, and methods of use.

Group IV, claim(s) 22-31, drawn to compounds of Formula 4A, pharmaceutical compositions, and methods of use.

The inventions listed as Groups I-IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: Each group is drawn to structurally different and chemically divergent compounds.